COST ALLOCATION STUDY
FOR THE
MONTANA STATE HIGHWAY SYSTEM:
1999 UPDATE

Prepared by:

Jerry Stephens and Nate Menuez
Department of Civil Engineering
Montana State University
Bozeman, Montana 59717

Prepared for:

Montana Department of Transportation
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Helena, Montana 59620-1001

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16. Abstract

This study found that personal vehicles, single units, and combination trucks were generally paying their fair share of the costs of the Montana state highway system during the study period (1994 to 1996). Equity ratios, defined as the ratio of the percent of revenues to the percent of expenditures allocated to a group of vehicles, were calculated for various types of vehicles for state and federal funds used on the system. The equity ratios for state funds for personal vehicles (automobiles and pickups), single units, and combination trucks were 0.96, 1.17 and 1.04, respectively. Thus, personal vehicles were found to be nominally under paying their relative cost responsibility for the highway system, while single units and combination trucks were found to be nominally over paying their relative cost responsibility. The equity ratios by vehicle type for federal funds were not as closely grouped around unity. Equity ratios of 0.87, 1.44, and 1.14 were calculated for federal funds used on the state highway system for personal vehicles, single units, and combination trucks, respectively. Equity ratios for state and federal funds combined for personal vehicles, single units, and combination trucks were 0.95, 1.28, and 1.04, respectively.

Some inequities in user payments were observed between the individual classes of vehicles that made up the broad categories of personal vehicles, single units, and combination trucks. Within the personal vehicle category, for example, the state equity ratios for automobiles and pickups were 0.86 and 1.14, respectively. Within single units, 3 and 4+ axle single units had state equity ratios around 2.0, while busses had an equity ratio of 0.42. In the category of combination trucks, equity ratios ranged from 0.81 to 1.88, with the lowest equity ratios being calculated for the largest double trailer units. Finally, equity for a given vehicle configuration varied significantly with specific vehicle operating weight (lower equity ratios were consistently found for higher operating weights).

With respect to the sufficiency of user revenues to cover expenditures, state revenues and expenditures on the system approximately balanced. Federal expenditures on the system, however, were significantly higher than federal revenues attributable to Montana sources. The deficit between federal revenues and expenditures ranged from 0.71 to 2.77 cents per mile for personal vehicles and combination trucks, respectively. This study also found that highway costs in Montana were higher than average federal highway costs across the country (by approximately 1 cent per vehicle mile driven).

The results presented above were all determined using a cost occasioned approach to highway cost allocation. Following this methodology, system revenues were allocated back to the vehicles that paid them, while costs were allocated back to the vehicles whose demands occasioned them. These analyses were performed using algorithms developed specifically for this study and using cost allocation software being developed by the Federal Highway Administration (FHWA). Both calculations yielded similar equity results for state revenues and expenditures. The FWHA software generated higher equity ratios for personal vehicles relative to trucks than were calculated using the algorithms developed specifically for this study. This difference was attributed to differences in the pavement cost allocation in the two calculations for the non-interstate NHS and secondary highway systems.

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EXECUTIVE SUMMARY

Cost Allocation Study for the Montana State Highway System:
1999 Update

Jerry Stephens
and
Nate Menuez
Montana State University

The objective of this study was to review revenues and expenditures for the state highway system in Montana to determine if the various users of the system were equitably sharing the costs of providing them with highway service. This study was an update of the 1992 cost allocation study, and it was conducted in light of several changes that have occurred since that study with respect to the funding and use of the highway system. These changes include revisions in fuel tax rates, adoption of a new basis and schedule for levying motor carrier fees, changes in patterns of vehicle use, changes in expenditure patterns, and improvements in the data and methodologies available to support cost allocation studies. The study was based on historical revenues and expenditures in the period 1994 to 1996. During this period, an average of $271,267,000 in revenue was collected annually from system users to be used on the highway system, while an average of $320,842,000 was spent each year to provide these users with highway service. State funds accounted for 66 and 52 percent, respectively, of the revenues and expenditures on the state highway system. The remaining revenue was collected by the federal government, and the remaining expenditures were funded from the federal Highway Trust Fund. Note that average annual expenditures exceeded programmed highway revenues by 18 percent during the study period. While state revenues and expenditures were on the same order of magnitude each year, the federal government spent an average of 68 percent more money on federal aid highways in Montana than they collected in highway revenue from the users of this system. While the 1992 study treated only state derived revenue and subsequent expenditures of this revenue on the highway system, this study was expanded to also include an analysis of federal funds collected and used on the state highway system in Montana.

The steps required to accomplish the objectives of this study consisted of:

1) allocating the revenue used to fund the highway system back to the vehicles from which it was collected,
2) allocating the costs of providing highway service back to the vehicles whose demands occasioned them, and
3) comparing these allocated revenues and allocated costs to determine if highway users have been equitably sharing the expense of providing them with highway service.

This approach to assessing equity of user fee payments, referred to as the "cost occasioned" approach to highway cost allocation, is the most commonly used approach for performing such studies (and it was the primary approach used on the recent federal cost allocation study). The revenues considered in these analyses consisted only of revenues subsequently used to fund construction, operation, or maintenance of the state highway system. The expenditures considered in these analyses were the direct agency costs incurred during each year of the study period; external costs associated with the existence and use of the highway system (costs of

congestion, environmental impacts, etc.) were not included in this study. While these external costs may be significant, they presently can not be calculated with sufficient confidence to include them in this study.

With respect to state revenues used to fund the highway system, personal vehicles (automobiles and pickups), single units (trucks and busses), and combination trucks were found to be responsible for 65, 9, and 26 percent of this revenue. State funds used on the highway system came almost exclusively from user taxes and fees. Sources of state highway revenues included fuel taxes (81 percent), weight fees (12 percent), new vehicle sales tax receipts (5 percent), and other miscellaneous fees and disbursements (2 percent). Records available on these revenues generally consisted of the total revenue collected, with only nominal information on their source by vehicle type. Thus, the revenue allocation process consisted of using any information that was available on revenue by vehicle type, in conjunction with knowledge of the basis upon which the taxes and fees were levied, to estimate fee payments by vehicle class.

Personal vehicles, single units, and combination trucks were found to be responsible for 51, 9, and 40 percent of federal highway revenue attributable to Montana. Sources of federal highway revenues were similar in type to those of the state, and included fuel taxes (81 percent), truck and trailer sales taxes (12 percent), heavy vehicle use taxes (5 percent), and tire taxes (3 percent).

With respect to expenditures on the highway system, personal vehicles, single units, and combination trucks were found to be responsible for 67, 8, and 25 percent of expenditures of state funds on the system. State funds were used on all the activities associated with constructing, maintaining, and operating the state highway system, including general operations (6 percent), construction (41 percent), maintenance (37 percent), highway patrol (10 percent) bond interest (4 percent) and other miscellaneous activities (2 percent). The expenditure allocation process consisted of using engineering and other principles to relate physical demands from specific vehicles to certain features of the highway system (e.g., heavy trucks and thicker pavements), and then assigning costs to these features of the system.

Personal vehicles, single units and combination trucks were found to be responsible for 59, 6, and 35 percent of the expenditures of federal funds on the state highway system. These federal cost responsibilities differ from those of the state because federal funds, by law, were restricted to funding construction activities.

The revenue and expenditure allocations given above were used to calculate equity ratios for the different classes of vehicles that use the highway system. These equity ratios were defined as the percent of allocated revenues for a vehicle class divided by the percent of allocated expenditures. Thus, an equity ratio greater than one indicated that a group of vehicles was overpaying their cost responsibility relative to the other vehicles in the traffic stream (percent of revenue exceeds percent of expenditures), while an equity ratio less than one indicated that they were underpaying their cost responsibility relative to other vehicles in the traffic stream (percent of revenues less than percent of expenditures).

Following the equity ratio approach, users of the state highway system were generally found to be paying their fair share of the costs of providing them with highway service. Equity ratios of 0.96, 1.17, and 1.04 were calculated for personal vehicles, single units, and combination trucks, respectively, for state revenues and expenditures on the highway system. These ratios range closely around 1.00; they indicate that personal vehicles were nominally under paying the relative costs of providing them with highway service, while single units and combination trucks were nominally over paying the relative costs of providing them with highway service. Greater

disparities in equity were observed between the individual vehicle classes within the broad categories of personal vehicles, single units, and combination trucks. Within the category of personal vehicles, the equity ratios for automobiles and pickups were 0.86 and 1.14, respectively, indicating automobiles were relatively under paying their relative cost responsibility while pickup trucks were over paying their cost responsibility. Within the category of single units, 3 and 4+ axle single units were found to be significantly over paying their relative cost responsibility, with equity ratios of 1.85 and 2.13, respectively. Conversely, busses were found to be significantly under paying their cost responsibility, with an equity ratio of 0.42. The equity ratios for combination trucks ranged from 0.81 to 1.88, with the lowest equity ratios calculated for the largest double trailer configurations. Disparities were also observed for individual vehicles of the same configuration operating at different weights. A five axle tractor, semi-trailer registered at 80,000 pounds, for example, was found to have an equity ratio of 0.9 at an operating weight of 80,000 pounds, while its equity ratio increased to 1.2 at an operating weight of 70,000 pounds.

The equity ratios calculated for federal revenues and expenditures for the highway system were 0.87, 1.44, and 1.14, respectively, for personal vehicles, single units, and combination trucks. Federal equity ratios, in general, ranged more widely around 1.00 than state equity ratios. Some of the trends observed in the state equity ratios by vehicle class were also observed in the federal equity ratios, that is, a) automobiles had an equity ratio less than 1.0, while pickups had an equity ratio greater than 1.0, b) large single units (3 and 4+ axle) had equity ratios significantly greater than 1.0, and c) busses had an equity ratio considerably lower than 1.0. Results from this analysis of federal financing of the highway system were compared with those determined by the Federal Highway Administration (FHWA) in their recent federal highway cost allocation study. The equity ratios determined in that study for personal vehicles, single units, and combination trucks were 1.05, 0.86, and 0.95, respectively. While FHWA's results differed from those obtained in this study, it is important in addressing this difference to recognize that all highway users in Montana under pay their federal cost responsibility for highway service. Thus, the equity ratios obtained in this study simply indicate that single units and combination trucks are under paying their cost responsibility less than personal vehicles. Personal vehicles, single units, and combination trucks were found to be under paying their cost responsibility for federal expenditures on the Montana highway system by 0.71, 0.53, and 2.77 cents per mile, respectively.

Equity ratios for combined state and federal funds used on the highway system ranged fairly closely around 1.00 for the broad vehicle classes considered in this study. Equity ratios of 0.95, 1.28, and 1.00 were calculated for personal vehicles, single units, and combination trucks, respectively.

The equity of state highway revenues and expenditures by vehicle class was also investigated using highway cost allocation software being developed by FWHA. Note that only a preliminary version of this software was available at the time of this study. The software is being developed from the analysis algorithms assembled for the recent federal highway cost allocation study. The software uses the same cost occasioned approach to highway cost allocation as was used by Montana State University (MSU) in the analysis described above. The FHWA software was run using the same input data and allocation strategies as were used in the MSU analysis. The FHWA software produced equity ratios of 1.04, 1.00, and 0.91, respectively, for personal vehicles, single units, and combination trucks. As observed in the MSU analysis, these ratios are all clustered closely around 1.0. The primary difference between the MSU and

FHWA results was a consistent shift in the magnitude of the equity ratios with vehicle size. The MSU analysis indicated nominal underpayment of relative cost responsibility by personal vehicles with an equity ratio of 0.96, while the FWHA software indicated a nominal over payment of cost responsibility for personal vehicles with an equity ratio of 1.04. This situation was reversed for combination vehicles, with the MSU and FHWA analyses generating equity ratios of 1.04 and 0.91, respectively, for these vehicles. This difference in results was very specifically traced to differences in the allocation of pavement construction costs on the non-interstate NHS and secondary highway systems. The FHWA analysis uses a new pavement deterioration model developed for the federal cost allocation study. While this model implements a contemporary mechanistic approach to pavement deterioration, the model has not been extensively exercised or evaluated outside of the federal cost allocation effort. Additional work needs to be done to insure that the performance of pavements in Montana is being accurately represented in the FHWA program. Note that considerable work has been done to customize the AASHTO ESAL model of pavement deterioration used in the MSU analysis so that it reasonably represents actual road performance in Montana.

Elimination of the new vehicle sales tax and the implementation of a new light vehicle fee schedule (actions of the 1999 Montana state legislature) were expected to have minimal impacts on the equity and sufficiency of state funds used on the highway system. Other actions, however, that could affect user equity at the state level and that may therefore merit future consideration are a) the increase in construction spending expected under the re-authorized federal highway bill and b) the assumption by the state of responsibility for maintenance activities on the secondary system beginning in the year 2000.

COST ALLOCATION STUDY FOR THE MONTANA STATE HIGHWAY SYSTEM: 1999 UPDATE

1. INTRODUCTION

1.1 GENERAL REMARKS

Traditionally, of the many services provided by government, the highway system is partially or completely paid for by the people that use it. User fees take several forms, including fees related to the amount of use and level of demand a vehicle places on the system (e.g., fuel taxes and gross weight fees, respectively) and fees independent of these parameters (e.g., flat registration fees). These monies collected from the users, possibly supplemented by public funds of a more general source, are then spent to build and maintain the highway system in such a fashion as to provide an equal service and benefit to all. Under an equitable fee system, the monies collected from (and/or associated with) each user will be proportional to the expense of providing that user with highway service.

The fairness of the motor vehicle fee structure can be determined by comparing revenues to expenditures for various classes of users. Determining the equity of these fees is a complex problem, due to major differences in the types of vehicles that use the highway system (e.g., passenger car, versus 3 axle dump truck, versus tractor, semi-trailer, etc.) and the associated differences in the fees they pay and the impacts that they have on the system. Investigations to determine equity between user payments are commonly referred to as highway cost allocation studies or cost responsibility studies. The most recent cost allocation study for Montana was conducted in 1992 (Stephens, Barth, and Cloud, et al, 1992). That study addressed the relative equity of the highway fees paid by motor vehicle operators to the state of Montana that were subsequently used to fund the state highway system. To conduct the study, revenues and expenditures over a four year period (1988 to 1991) were allocated to three broad classifications of highway user, namely, basic (light) vehicles, intermediate vehicles, and heavy vehicles. An equity ratio, defined as the ratio of allocated revenue to allocated expenditures, was calculated for each vehicle class. The equity ratios calculated for basic, intermediate, and heavy vehicles were 0.96, 1.11, and 1.07, respectively. Thus, passenger vehicles were found to be nominally

under paying for their use of the highway system; single units and combination vehicles were found to be nominally over paying for their use of the system. It was further observed in the study that insufficient revenue was being collected from all users of the highway system to cover state expenditures on the system (revenues were only an average of 94 percent of expenditures).

As highway use, fee structures, and expenditure patterns, etc. may change over time, studies like the 1992 Montana Cost Allocation Study need to be periodically updated, if the results are to be used by policy makers in evaluating highway funding issues. Since the 1992 study, for example, fuel tax rates in Montana were increased, a new schedule for levying gross weight fees on combination vehicles was adopted (shift from levying separate weight related fees on towing units and trailers to levying equivalent fees on only the towing units), and the diesel fuel tax collection program was modified (the point of fuel tax collection was shifted). Changes may have also occurred in patterns of vehicle use and in the attendant manner in which highway revenues are spent to meet the demands these vehicles place on the aging highway infrastructure. Finally, note that highway cost allocation is an evolving field of analysis, and thus new ideas and methodologies for conducting such studies have been introduced since completion of the 1992 study. In this regard, the federal government just finished updating their 1982 cost allocation study, in an effort that included considerable work on new allocation algorithms for highway construction costs (FHWA, 1997).

Local, state, and federal agencies are all involved in collecting fees and performing various tasks to support different elements of the highway system. These agencies frequently assume responsibility for different activities on the same highways. Many studies have been conducted that consider the equity of revenues and expenditures associated with a single government entity. This approach has been justified on the basis that each entity functions independently, and thus equity and sufficiency issues can only be addressed within each entity. This approach has been criticized as offering an incomplete and possibly distorted view of equity and sufficiency. Policymakers at all levels of government may be able to make more rational decisions regarding the highway system if a comprehensive view of system equity is available rather simply the equity situation for a single government entity.

1.2 OBJECTIVE AND SCOPE

The primary objective of this project was to determine if the various users of the state highway system in Montana are paying their fair share of the costs of providing them with highway service. This study is an update of the 1992 Montana cost allocation study (Stephens, Barth, and Cloud, 1992), and it was, to a large extent, conducted in a similar fashion to that study. The present study was expanded relative to the 1992 study to include both federal and state revenue and expenditures on the state highway system in Montana. Note that while ideally the local road system would be included as part of this study, data on this system is sparse. A major effort would be required to collect the data necessary to perform cost allocation analyses on the local road system, and the considerable resources required to support such a data collection effort are simply unavailable. The current study was expanded relative to the 1992 study with respect to the level of detail considered from a vehicle configuration perspective. Revenues and expenditures were determined for eighteen individual vehicle configurations and for specific ranges of operating weights for certain configurations, rather than only the broad categories of basic, intermediate, and heavy vehicles used in the 1992 study.

As is typically done in highway cost allocation investigations, this study was performed by assigning revenues collected from highway users back to the specific configurations that paid them and allocating expenditures (costs) back to the specific users that occasioned them. Thus, the study effort primarily consisted of collecting and analyzing data available from various government agencies on revenues, expenditures, and use of the state highway system. These tasks were accomplished generally in accordance with accepted cost allocation methodologies, as modified and further developed to fit conditions in Montana. Notable features of the algorithms developed and used in this study include the use of a traditional AASHTO ESAL approach (customized to Montana) in allocating pavement costs and the use of an incremental allowable stress based bridge analysis to assign bridge costs.

The data collected for the study data was also input into a new highway cost allocation analysis package being developed by the Federal Highway Administration (FHWA, 1999). This package also assigns revenue back to the users from which it was collected, and it allocates costs back to the users that occasion them. The most notable difference in the algorithms used in the FHWA program from those implemented in the Montana analysis is the use by FHWA of a new national pavement cost model (NAPCOM) to assign pavement costs back to the users that occasion them.

The results of the revenue and expenditure allocation analyses (from both the MSU and the FHWA algorithms) were used to calculate equity ratios for each vehicle class. As previously stated, these ratios were calculated as the percent of total revenue attributable to a vehicle class divided by the percent of total costs occasioned in providing highway service to that vehicle class. Thus, an equity ratio greater than one indicates that a class of vehicles is overpaying its fair share of highway costs compared to other classes; an equity ratio less than one, that a class of vehicles is underpaying its fair share. Using the algorithms developed at MSU, equity ratios of 0.96, 1.17, and 1.04, respectively, were calculated for personal vehicles, single units, and combination trucks for state revenues and expenditures. Using the federal analysis package for state revenues and expenditures resulted in equity ratios of 1.04, 1.00, and 0.91, respectively, for personal vehicles, single units, and combination vehicles. The primary reason for the differences in these results is related to the manner in which pavement costs were allocated by the two programs. The federal program appeared to assign a substantially greater amount of pavement deterioration on Montana's secondary road system to load related effects compared to the algorithm developed by MSU. In light of this situation, further work needs to be done with the federal program to insure that the software is accurately representing pavement performance in Montana. The pavement model used in the MSU analysis has been customized to conditions in Montana, and it has been used in several previous infrastructure studies.

Relative to the uncertainties inherent in either analysis approach, the equity ratios reported above are similar in magnitude and range closely around 1.0. A greater disparity in equity was observed for federal funds used on the state highway system. Equity ratios of 0.87, 1.44, and 1.14 were calculated for personal vehicles, single units, and combinations, respectively, for federal funds used on the system.

The completed analyses from a cost allocation study can subsequently be used to investigate effects of changes in highway financing on the relative equity of user fee payments. The only such change investigated in this study was the elimination of the new vehicle sales tax and the replacement of this tax (and the vehicle property tax) by a single fee assessed on light vehicles. This tax initiative was passed by the 1999 Montana legislature, and it will be voted on by the citizens of Montana in November, 2000. The change was found to have only nominal effect on the equity and sufficiency of state user fees.

2. STUDY PARAMETERS

2.1 GENERAL REMARKS

This study was done using the “cost occasioned” approach to highway cost allocation. While this approach is both well developed and often used for highway cost allocation studies, many features in its implementation vary between applications. Thus, both a general description of the methodology, as well as a description of some of the specific features of its implementation for this study, are presented below. A brief description of the state highway system (covering both the physical infrastructure and its users) is then presented to provide some perspective from which the cost allocation analyses and results can be evaluated. Finally, background information is provided on the financing of the system. An overview is provided of both the revenues available to the system and the manner in which these revenues were expended to build, maintain, and operate the system during the study period.

2.2 STUDY APPROACH

Three methodologies are frequently mentioned in association with conducting cost allocation studies, namely, cost occasioned, benefits based, and marginal cost approaches. The cost occasioned approach was used in this study. This methodology has been used in the majority of state cost allocation studies (e.g., Delaware, 1992, Idaho, 1994, Oregon, 1995, etc.), including the 1992 Montana study, and it was the primary methodology used in the recent federal cost allocation study (FHWA, 1997). As the name implies, this approach involves assigning the costs of providing highway service to the vehicles that occasion them. Heavy vehicles, for example, are assigned a common cost with all other vehicles for a baseline bridge facility on the system, plus an additional cost associated with strengthening the baseline facility to carry heavy vehicles. The revenues collected from various classes of vehicles are also identified and assigned back to the vehicle classes from which they were collected. Equity ratios are then calculated for each vehicle class from their allocated revenues and expenditures to establish if they are paying their fair share of highway costs relative to the other vehicles in the traffic stream.

While the cost occasioned approach to cost allocation studies is conceptually straightforward, some of the subtle features of its use merit further comment. In assessing equity in this fashion, the assumption is implicitly made that users are equally satisfied with the level of highway service that is being provided at current funding levels. Often in following the cost occasioned approach, insufficient data is available to definitively determine appropriate factors to allocate specific revenue and/or cost items to particular vehicle configurations. In such situations, allocators must be determined based on a combination of judgement and engineering principles. In other instances, the analytical models that are available to assess the effects caused by different vehicles are inexact and/or imperfect. In light of this situation, individual state cost allocation studies are unique, as efforts are made to choose optimum allocation strategies and methodologies for the specific revenue, expenditure, and conditions of highway use encountered in each state. The specific allocation strategies and methodologies used in this study for revenue and expenditure allocation by vehicle type consistent with conditions in Montana are discussed in detail in Sections 3 and 4 of this report.

In implementing the cost occassioned approach to highway cost allocation, questions often arise with respect to the specific revenues and costs that should or must be considered as part of the study. The revenues in question generally are fees collected directly from highway users that are not, in turn, used to finance the operation of the highway system. The costs in question are a) the attendant agency expenditures on items other than operation of the highway system and b) the costs associated with adverse effects of system operation that are not directly paid by highway users, often referred to as externalities. Naturally, inclusion or exclusion of such items can effect equity results, depending on the type of revenue or expenditure and nature of its allocation.

The decision was made in this study to exclude from consideration a) any revenue collected from users that was subsequently used for non-highway purposes and b) any expenditures by MDT on activities outside of constructing, maintaining, and operating the highway system. Such revenues and expenditures were viewed as extraneous to the fundamental idea of user fees paying for the cost of providing highway service. This approach of considering only “highway” related dollars in the cost allocation process has reportedly been used by several states; other states have elected to include all highway user revenues, regardless of how they are spent, in their equity analyses (FHWA, 1997). Some of the analyses in the

federal cost allocation study were conducted both including and excluding revenues that ultimately were used for non-highway purposes. Note that almost all of the money (fully 88 percent) collected from highway users by the state of Montana was used by the state department of transportation to build, maintain, and operate the state highway system (see Section 4).

Increasing interest has been expressed in the cost allocation community in including external costs in the cost allocation process. Such costs are those costs that incidentally result from the existence and use of a highway system that are not directly paid by users of the system (e.g., increased medical costs associated with health problems generated by vehicle emissions). Inclusion and treatment of these costs (possibly balanced by consideration of external benefits of having a highway system) is a controversial issue. Efforts have been made (and continue to be made) to assign dollar values to the "primary" external effects of highway use. Primary "externalities" include air pollution, water pollution, noise pollution, accidents, and congestion. Marginal costs of congestion, crashes, and noise pollution, for example, were estimated in the 1997 Federal cost allocation study (FHWA, 1997) to be 20.1, 1.2, and 3.0 cents per vehicle mile driven for a 5 axle tractor, semi-trailer operating on an urban interstate. Note that the marginal pavement related cost estimated for the same situation was 40.9 cents per mile. On a rural interstate, the marginal cost of congestion, crashes, and noise pollution for a 5 axle tractor, semi-trailer were estimated to be 2.2, 0.9, and 0.2 cents per mile driven (versus pavement related costs of 12.7 cents per mile).

While the costs presented above for externalities appear precise, estimates of these costs vary significantly in magnitude, as is pointed out by the authors of the federal cost allocation study. FHWA reported, for example, that the estimated marginal costs for congestion on rural highways ranges from 1.0 to 10.9 cents per mile for combination trucks (FHWA, 1997). With respect to air pollution (for which costs were not reported in the Federal cost allocation study), the costs associated with nitrous oxides released in the atmosphere, for example, reportedly range from $92 to $33,000 per ton of pollutant (Battelle, 1995).

Based on the above considerations, the conclusion was reached that external costs cannot be presently calculated with sufficient confidence to include them in this study. In reaching this conclusion, it is important to recognize that these costs may be of a sufficient magnitude, even in rural areas, that they should be revisited in the future. Note that while a substantial investigation of external costs was conducted as part of the recent federal cost allocation study, the primary

results of the study focused on equity analyses that excluded external costs. No state studies have been located to-date in which external costs have been considered.

The equity ratios calculated by the cost occasioned approach, as described above, do not reflect the sufficiency of user fees to cover direct highway costs. To some extent, equity and sufficiency can be reasonably addressed independently. Society may elect to either under or overcharge for highway transportation services for a variety of social and economic reasons. In either case, both the sufficiency and the relative equity of user payments are of interest to policy makers. Sufficiency is easily determined from the data collected under the cost occasioned approach to cost allocation, even though it is not always explicitly commented on. Knowledge of both equity and sufficiency is useful in formulating and evaluating possible changes in the highway fee structure.

With respect to the benefits based and marginal cost approaches to investigating the equity of highway user fees, neither of these methodologies has been practically used in previous cost allocation studies. The benefits based approach allocates costs based on relative benefits received. Consistently and quantitatively assessing these benefits, however, is a difficult task. Extensive data on operating costs for various private sector industries would be required, for example, for the benefits accrued by these industries to be accurately evaluated. The marginal cost concept has been advanced as an approach to highway pricing that should result in efficient utilization of the highway system. The basic concept consists of charging highway users the total marginal costs of highway use. Such costs would include costs borne by other highway users and all non-users as a consequence of a user's choice to make a specific trip. While such an approach apparently is well grounded in economic principles, the data required to support the approach is extensive and the specific manner in which it should be applied to highway expenditures and revenues is somewhat uncertain. A basic marginal cost analysis was performed as part of the federal cost allocation study. This analysis apparently incorporated only pavement and external costs, and the results were generally qualitatively evaluated with respect to how well existing user fees can and do promote efficient use of the various elements of the system (notably, rural versus urban roadways) across different classes of vehicles.

The actual cost allocation calculations for this study were done using algorithms developed at MSU and programmed on spreadsheets. Historically, pre-programmed software has not been available for performing these calculations. In 1999, however, FHWA released a preliminary version of the first of such software (FHWA, 1999). This software was designed to assist states in performing cost allocation analyses using the cost occasioned approach. The

information collected for the MSU algorithms was reformatted and used in the FHWA program. The two programs yielded similar results. The decision was made to use the MSU results as the primary results from this investigation, as the MSU algorithms were specifically developed for conditions in Montana. While the FHWA software is fairly flexible in its range of application, it could not be fully manipulated a) to take maximum advantage of all the information available on specific sources of revenue by vehicle type and b) to implement allocation strategies judged to be appropriate in Montana for some categories of expenditures. The software also was still being validated at the time these analyses were performed.

2.3 STUDY PERIOD

The decision was made to do this cost allocation study and equity analysis using historical data. Some cost allocation studies elect to calculate equity for a future period of time based on forecasts of revenue and expenditures at that time (e.g., the federal cost allocation study). The reliability of these forecasts, however, can be uncertain, and thus a second approach employed in cost allocation studies is to perform the equity analyses using known historical data for a time period during which revenue and expenditure patterns are expected to be similar to those in the future. At the time that this study was initiated, it was believed that revenue, expenditure, and use information from the years 1994 to 1996 might reasonably represent conditions for the next several years. Further note that three years was judged to be the minimum acceptable period to reasonably characterize general use and expenditure patterns on the highway system. Since initiation of the study, however, the funding situation for Montana's highways has significantly changed. The federal transportation act, as re-authorized in 1998, includes a significant increase in federal funding for construction activities (approximately a 60 percent increase) on the system. This influx of money for a particular category of activity could have a major impact on user equity. A second action that could influence user equity occurred in 1999 at the state level and consisted of the state assuming maintenance responsibility (beginning in the year 2000) for paved secondary highways (Montana State Legislature, 1999a). Historically, maintenance of the secondary system was predominantly a county responsibility, while capital improvements were typically done by the state. Since this change affects a particular category of highway activity and a specific element of the highway system, it could have an impact on user equity. Finally, the state legislature also passed a bill in 1999 that could affect state highway revenues. Pending voter approval in November, 2000, the new vehicle sales tax (one of the sources of highway revenue) will be eliminated, and a new light vehicle fee will

be instituted. From a highway finance perspective, this bill was developed to be neutral with respect to highway funding, and it was also expected to have only a nominal effect on user equity (see Section 7 of this report).

In any event, the specific data used in the study actually cover three different 12 month periods, as transportation related data is variously tabulated based on the state fiscal year (which ends on June 30), the federal fiscal year (which ends on September 30), and the calendar year (which ends on December 31). While all data could have been adjusted to precisely the same start and finish date, the decision was made to simply use three years of consecutive data for any given parameter, with a start date matched as closely as possible with calendar years 1994 to 1996. This decision effectively resulted in the use of state revenue and expenditures for state fiscal years 1995 to 1997, federal revenue and expenditures for federal fiscal years 1994 to 1996, and traffic data for calendar years 1994 to 1996.

2.4 HIGHWAY SYSTEM

2.4.1 General Remarks

The highway infrastructure considered in this study consisted of the roadways and bridges (and their appurtenances) that were constructed, maintained, and/or operated by the Montana Department of Transportation (MDT) during the study period using state and federal funds. Notably, while MDT was generally responsible for performing all of these functions across the various elements of the state highway system, maintenance responsibility for the secondary and urban systems was predominantly a responsibility of local governments.

2.4.2 Roadway

In 1997, the federal aid interstate and non-interstate National Highway System, and the state primary, secondary, and urban systems totaled approximately 11,705 miles of highway in the state of Montana (MDT, 1997). A map of the system is shown in Figure 2.4.1-1. By virtue of being designated to one of these systems, a highway is eligible for one or more types of federal aid funding. Road surfaces on the Montana state highway system are constructed of asphalt (flexible), concrete (rigid), treated gravel, and gravel. The percent of each system paved with each type of material is reported in Table 2.4.2-1. Asphalt is the most commonly used material on state highways, comprising 80 percent of the roads on the state highway system.

Table 2.4.2-1 State Highway System Length by Federal Aid System (MDT, 1997a)

System	Length, Miles	Percent of length within each system by surface type		
		% Flexible	% Rigid	% Other[a]
Interstate	1,191	90	10	0
Non-Interstate NHS	2,668	97	0	3
Primary	2,833			
Secondary	4,665	58	0	43
Urban	350	85	1	14
Total	**11,705**	**80**	**1**	**19**

[a] bituminous surface treatment, gravel, or primitive

Only on the interstate system is concrete used to any major extent (10 percent), and most of this pavement is on a single interstate route (Interstate 90).

2.4.3 Bridges

A summary of the bridges in the state inventory is presented in Table 2.4.3-1. Bridges on the state highway system are constructed using three types of structural systems, namely, stringer, truss, and flat plate systems. Simply supported stringer bridges compromise 70 percent of all spans (by length) on the state highway system. Continuous stringer bridges compromise 25 percent of the bridges on the system. Flat plate bridges and truss bridges comprise only 5 percent of the bridges on the state highway system. With respect to materials, bridges in Montana are constructed with prestressed concrete, concrete, steel, and wood. The most common bridge on the system is the simply supported, prestressed concrete stringer bridge. These bridges comprise 46 percent of all the bridges on the system (based on length), and they represent even higher proportions of the bridges on the interstate system (65 percent). Most new and replacement bridges are being constructed using this material (Murphy, 1995). Standard prestressed bridge designs have been developed by MDT based on span length and roadway width. Continuous steel stringer bridges are the second most common bridge on the system, comprising 24 percent of all bridges (by length). Timber bridges comprise a significant part of

Table 2.4.3-1 Characteristics of Bridges on the State Highway System (MDT, 1994)

Structural System	No. of Spans	Average Length, ft	% (by length) of all spans
Stringer			
Simply supported			
Prestress	3,005	59	46
Steel	571	56	8
Wood	2,152	20	11
Concrete	437	42	5
Continuous			
Prestress	3	103	0
Steel	886	104	24
Concrete	160	22	1
Total	**7,214**	**51**	**95**
Flat Plate			
Simply supported			
Concrete	79	20	0
Continuous			
Concrete	442	20	2
Total	**521**	**20**	**2**
Truss			
Steel	85	130	3
Total	**85**	**130**	**3**
Total	**7,820**	**50**	**100**

the inventory (11 percent). Most of the timber bridges are on the primary and secondary systems.

2.5 HIGHWAY USE

2.5.1 Types of Vehicles (Physical Configurations)

For the purposes of this study, all vehicles operating on the Montana state highway system were classified according to the 18 vehicle configurations shown in Figure 2.5.1-1. These classifications were further aggregated into three broad categories, namely personal vehicles (automobiles and pickups), single units (commercial 2, 3, and 4+ axle trucks and busses), and combination trucks (tractor, semi-trailers and straight trucks, with trailers).

Vehicle configurations in Montana are controlled by legal limits that include requirements on load per unit width of tire, maximum axle group weights, maximum gross vehicle weights, maximum vehicle lengths, and maximum vehicle widths (MCA, 1997). Various vehicle configurations that have evolved under these limits are shown in Figure 2.5.1-1. While vehicle size and weight limits in Montana are generally consistent with regulations around the country, some features of Montana's laws are specific to the western United States and more particularly to the state of Montana. Specific regulations of interest include:

1) maximum gross vehicle weights are determined by the Federal Bridge Formula B,
2) long combination vehicles (LCVs) are allowed to operate, and
3) triple trailers are allowed to operate on the interstate system.

With regard to maximum gross vehicle weights, Montana has elected not to adopt the 80,000 lb maximum gross vehicle weight used by the federal government, but rather to control demands placed on bridges using Federal Bridge Formula B. This formula gives the allowable weight on any group of two or more axles in terms of the number and spacing of the axles,

$$W = 500 \, [LN/(N-1) + 12N + 36]$$

where,

W = allowable weight on the collection of axles under consideration, pounds
L = length between extreme axles in collection of axles under consideration, feet
N = number of axles under consideration

Within the constraints of the Bridge Formula B and maximum axle weights, Montana allows double trailer units up to 100 ft long to operate on the state's highways with a special permit. Double trailer units up to 75 ft long can operate without a permit. A popular double trailer vehicle configuration, referred to as the Rocky Mountain double, has either 7, 8 or even 9 axles and can operate at gross vehicle weights up to approximately 114,000; 118,000; and 123,000 pounds, respectively. These vehicles often run with two trailers with lengths of 45 and 28 ft. Axle loads in Montana are limited to 20,000; 34,000; and 42,500 pounds on singles, tandems, and tridems, respectively (with tridems controlled by the Bridge Formula). Loads on axles with single tires (except the steering axle) are limited to 500 pounds per inch of width (MCA, 1997).

2.5.2 Traffic

The average daily traffic on the various elements of the state highway system during the study period is summarized in Table 2.5.2-1. The largest volume of traffic was on the urban and interstate systems (ADT of 5,000 to 6,000 vehicles); the smallest volume of traffic, on the secondary system (ADT of 375 vehicles). These values were calculated using information provided by MDT. Data on the specific vehicle configurations that operate around the state are collected by the Data and Statistics Bureau of MDT. The data consist of visual classification counts, automatic vehicle classification counts, and weight and classification data collected at static weigh stations. These data collection activities are focused on the interstate , NHS, and primary systems, where much of the vehicle activity in the state is focused. Based on this data, MDT estimated the composition of the traffic stream on every mile of highway in the state for NHS interstate and non-interstate routes and for all state primary, secondary, and urban routes.

Traffic in Montana is relatively "light" compared to most other locations in the United States. Annual average daily traffic (AADT) in Montana in 1996 was 874 vehicles per lane, which is only one-third of the national average of 2453 vehicles per lane (FHWA, 1997a).

Information on vehicle operating weights by configuration was also obtained from MDT. All of the data collected from 32 static weigh station sites around the state in 1994, 1995, 1996 were used in the study. Note that the operation of overweight vehicles may not be well represented in static weigh station data. The state of Montana has only limited information on the percentage of overweight vehicles that operate on the highways. While overweight vehicle

Table 2.5.2-1 Daily Traffic on the State Highway System (average value across calendar years 1994 to 1996, based on data provided by MDT (1997b))

Element of the System	Average Daily Traffic (ADT)
Interstate	5179
NHS	2261
Primary	1067
Secondary	375
Urban	5982
Total	**1646**

operations can be characterized from weigh-in-motion data, such data is still only available at certain locations around the state, and systems for evaluating and processing this data are still being developed. Therefore, the decision was made to do this analysis without correcting the static weight data for overweight vehicles believed to be in the existing traffic stream.

Highway use can be expressed in terms of several parameters, including vehicle miles of travel (VMT), axle miles of travel (AMT), and ESAL miles of travel (ESAL-M). Average annual values for some of these parameters across the study period are given in Table 2.5.2-2 for each vehicle configuration. VMT is simply the number of vehicles on a highway multiplied by the miles they travel. If additional information is available on specific characteristics of the vehicles, quantities such as AMT,and ESAL-M can be calculated from VMT. For each vehicle configuration, for example, AMT was simply calculated as VMT multiplied by the number of axles for the configuration.

ESAL-M is a measure of the physical demands vehicles place on the roadway (notably, the base and running surface). ESAL-M was calculated for each class of vehicles by multiplying VMT by the ESAL factor for that class. The ESAL concept was developed for design purposes to calculate the design demand on a roadway subjected to a mixed stream of vehicles (AASHTO, 1993). The ESAL factor of a vehicle is related to both the type of axles on the vehicle, the loads they carry, and the type of pavement on which the vehicle is operated. The factor represents the number of passages of an 18,000 pound single axle that would damage the pavement an amount equivalent to the single passage of the vehicle in question (equivalent single axle load, ESAL). For a particular vehicle, the ESAL factor is calculated as the sum of the ESAL values for each axle comprising the vehicle. Relationships between axle loads and ESALs were developed from the results of the AASHO Road Test (Highway Research Board, 1962). The relationship between ESAL factor and axle load is non-linear, that is, as axle load increases, the ESAL factor increases in a fourth order relationship. ESAL factors were calculated for each vehicle configuration by MDT using weight and configuration data available from weigh station operations.

Referring to Table 2.5.2-2, personal vehicles accounted for 87 percent of all VMT, while they were only responsible for 3 percent of ESAL-M of travel. Conversely, combination trucks

Table 2.5.2-2 System Use by Vehicle Class (average annual values over the study period, based on data provided by MDT (1997b))

Category of Vehicle	Level of Use					
	VMT		ESAL-M		AMT	
	Miles (1000000s)	%	Miles (1000000s)	%	Miles (1000000s)	%
Auto	3,940	56.0	4	0.4	7,880	48.9
Pickup	2,191	31.2	25	2.4	4,382	27.2
Personal Veh	**6,131**	**87.2**	**28**	**2.8**	**12,262**	**76.0**
SU2	169	2.4	58	5.6	337	2.1
SU3	73	1.0	42	4.1	219	1.4
SU4+	8	0.1	12	1.1	32	0.2
Bus	30	0.4	8	0.8	68	0.4
Single Units	**280**	**4.0**	**120**	**11.5**	**656**	**4.1**
CS3	19	0.3	12	1.1	57	0.4
CS4	34	0.5	18	1.8	134	0.8
CS5	368	5.2	571	55.1	1,838	11.4
CS6	30	0.4	48	4.6	178	1.1
CS7+	1	0.0	1	0.1	7	0.0
CT4-	41	0.6	12	1.1	154	1.0
CT5	27	0.4	57	5.5	136	0.8
CT6+	16	0.2	21	2.0	94	0.6
DS5	8	0.1	15	1.5	39	0.2
DS6	8	0.1	10	1.0	46	0.3
DS7	35	0.5	66	6.3	245	1.5
DS8+	35	0.5	58	5.6	282	1.7
Combination Trucks	**621**	**8.8**	**889**	**85.7**	**3,210**	**19.9**
Total	**7,032**	**100.0**	**1,037**	**100.0**	**16,128**	**100.0**

were responsible for only 9 percent of VMT, but they accounted for fully 86 percent of ESAL-M. This situation has significant implications from a cost allocation perspective. Personal vehicles, for example, would be expected to bear the majority of any costs allocated based on use measured by VMT (i.e., common costs), while combination trucks would be expected to bear the majority of any costs allocated based on ESAL-M (i.e., pavement costs). These allocations are discussed in detail in Section 4 of this report.

2.6 SYSTEM FINANCING

2.6.1 General Remarks

Revenue to operate the Montana state highway system comes from a combination of state and federal sources. State highway revenues and that portion of federal highway revenues attributable to the state of Montana averaged $327,737,000 annually during the study period. Over 95 percent of these funds were collected from taxes and fees paid by highway users. With respect to the disposition of this revenue, 88 percent of the state revenue and 74 percent of the federal revenue were programmed for highway purposes. Thus, approximately $271,267,000 was generated annually for the purpose of maintaining and operating the state highway system in Montana, with 67 and 33 percent of this funding coming from state and federal sources, respectively. Over this same time period, combined annual state and federal expenditures on the state highway system averaged approximately $320,842,000 (52 percent in state funds, 48 percent in federal funds). Note that average annual expenditures exceeded programmed highway revenues by 18 percent during the study period. While state revenues and expenditures were on the same order of magnitude each year, the federal government spent an average of 68 percent more money on federal aid highways in Montana than they collected in highway revenue from the users of this system.

2.6.2 Revenues

2.6.2.1 State Revenues – The majority of the state funds spent on the highway system during the study period came from fuel taxes, weight fees, new vehicle sales taxes, and miscellaneous user fees. The average annual revenue received by MDT from the state during fiscal years 1995 to 1997 is summarized in Table 2.6.2.1-1. Of the $205,709,000 received on average each year, $180,337,000 (88 percent) was used by MDT on the state highway system. The remaining

Table 2.6.2.1-1 Summary of Revenue Received by MDT from State Sources (based on information provided by MDT (1997c))

Revenue Use	Revenue Source	Average Annual Revenue ($1000s)	Percent of Revenue Within each Category of Use	Percent of All Revenue
Direct State Highway Use	Gasoline Tax	107,577	60	
	Diesel Fuel Tax	38,689	21	
	GVW Fees	21,198	12	
	New Vehicle Sales Tax	8,866	5	
	Miscellaneous	4,047	2	
Sub-total		**180,377**	**100**	**88**
Non-State Highways				
For Local Government	Gas and Diesel Tax	16,766	68	
Refund to Indian Tribes	Gasoline Tax	3,253	13	
Reimbursement for Mat'ls	Sales of material	4,630	19	
Sub-total		**24,649**	**100**	**12**
Accounting Adjustments		**683**		
Grand Total		**205,709**		**100**

revenue consisted of funds received by the department that were subsequently transferred to other entities (12 percent of the total revenue) and of fiscal adjustments to the state balance sheets (less than ½ percent of the total revenue). The transferred revenues consisted of:

1) distributions to local governments funded from state fuel tax revenues,
2) distributions to Indian tribes, funded from gasoline tax revenues, and
3) payments received for road building materials purchased in bulk by the state which were subsequently resold for use on highway projects.

The local government disbursement is mandated by Montana state law, with the intent of offsetting highway expenses incurred by local governments. This disbursement was deducted from gasoline and diesel fuel tax revenues in proportion to the magnitude of the total taxes collected on each type of fuel. This approach is consistent with assuming that local roads are used in the same proportion by gasoline and diesel powered vehicles as is observed across the entire state highway system. The tribal distribution was a refund to the tribes of state taxes collected on fuel used for reservation travel. The tribal distribution was assumed to correspond with gasoline use, and thus was funded from the gasoline tax (Kirby, 1999). Note that the fuel

tax receipts reported in Table 2.6.2-1 were adjusted by these amounts. The program in which the state purchased large quantities of road building materials and made them available, at cost, for road building purposes (and thereby realized the cost savings associated with large volume purchases) was discontinued after 1995.

Referring to Table 2.6.2.1-1, the majority of the state revenue used to fund the state highway system came from fuel taxes (81 percent of the $181,377,000 in total revenue used for highway purposes). State fuel tax rates during the study period were $0.27 and 0.2775 per gallon of gasoline and diesel fuel, respectively. Only that portion of the fuel tax used for highway purposes is presented in Table 2.6.2.1-1, with appropriate adjustments for refunds claimed for off-road use and for the local government and tribal disbursements discussed above. No adjustment was made for tax paid on fuel used off-road for which no refund was claimed. Revenue from this source was expected to be small in magnitude. Note that the proportion of fuel tax receipts attributable to diesel fuel versus gasoline increased during this study relative to the 1992 study. In this study, diesel fuel tax revenue accounted for 21 percent of all fuel tax revenue, while in the 1992 study, they only accounted for 14 percent of all fuel tax revenue. This increase in diesel fuel tax revenue may have resulted from a change collection procedure in 1994.

The second largest source of state highway revenue (12 percent) was gross vehicle weight fees collected by the Motor Carrier Services division of MDT. Basic GVW fees were collected annually from all vehicles of pickup truck size and larger in approximate proportion to the gross vehicle weight at which they are registered to operate. These fees were assessed on a graduated scale that started at $7.00 for a ½ ton pick-up, reaches $750.00 for a vehicle registered at 80,000 pounds, and continued to increase for higher registered weights at the rate of $46.00 per ton pounds (MCA, 1997). The intent of these fees was to offset, to some extent, the increased cost of providing heavier vehicles with highway service relative to lighter vehicles. Miscellaneous fees collected by the Motor Carrier Services division of MDT for special permits, fines, etc. were also included in this revenue category.

The tax levied on the sales of new vehicles was the third largest source of state highway revenue (5 percent). The new vehicle sales tax was collected on all sales of new motor vehicles (excepting trailers, semitrailers, and housetrailers) in consideration of the right to use the state highways (M.C.A., 1997). This tax ranged from 0.004 to 0.015 of the list price of the vehicle.

This revenue was allocated using information available from the motor vehicle department on revenue collected by body style and weight, augmented as necessary by inferences based on estimates of vehicle replacement rate, purchase price, and tax rate.

The remaining revenue used to fund the state highway system (only 2 percent of all state highway revenue) came from a variety of sources. These sources include revenues associated with the Coal Tax trust fund (1995 only).

2.6.2.2 Federal Revenue – Average annual federal revenues attributable to highway users in Montana were $122,028,000. The sources of this revenue, summarized in Table 2.6.2.2-1, consisted of fuel taxes, heavy vehicle use taxes (HVUT), sales taxes on trucks and trailers, and tire excise taxes. Of this revenue, 74 percent ($90,890) was deposited in the Highway Trust Fund. The remaining 26 percent of federal revenues were placed in the transit fund or used for deficit reduction. As in the case of state revenues, fuel tax was the predominant source of federal highway trust fund revenues (82 percent). Fuel tax rates during the study period were 18.4 and 24.4 cents per gallon on gasoline and diesel fuel, respectively. Note that one-quarter to one-third of these taxes (depending on the year) were used for the non-highway purposes cited above (FHWA, 1997a).

The second largest reported source of revenue for the federal Highway Trust Fund (14 percent of HTF revenue from Montana) was the tax levied on the sale of trucks and trailers with gross weights in excess of 33,000 and 26,000 pounds, respectively. This tax was levied at the rate of 12 percent of the retail sales price of these vehicles.

The Heavy Vehicle Use Tax (HVUT) was the third largest source of HTF revenue (5 percent). As the name implies, this tax was levied on heavy vehicles with the intent of offsetting to some extent the increased cost of providing these vehicles with highway service relative to lighter vehicles. The tax started at an annual rate of $100 dollars at a gross vehicle weight of 55,000 pounds and increased in magnitude to a constant maximum rate of $550 for all gross vehicles weights at and above 75,000 pounds.

The final source of federal HTF revenue attributable to Montana was the excise tax on tires. This tax, levied on tires that weighed more than 40 pounds, increased with increasing tire

Table 2.6.2.2-1 Summary of Revenue Received by the Federal Government Attributable to Montana Sources (developed from information available from FHWA (FHWA, 1995, 1996, 1997a)

Revenue Use	Revenue Source	Average Annual Revenue ($1000s)	Percent of Revenue Within each Category of Use	Percent of All Revenue
Highway	Gasoline Tax	48,169	53	
	Special Fuel Tax	26,151	29	
	Sales Tax	9,890	12	
	HVUT	4,135	5	
	Tire Tax	2,545	3	
Subtotal		**90,890**	**100**	**74**
Non-Highway				
Deficit Reduction	**Fuel Tax**	**31,138**	**100**	**26**
Grand Total		**122,028**	**-**	**100**

weight. Tire weight is an indirect indicator of tire load capacity. Thus, this tax resulted in higher taxes being collected from tires expected to be used in applications that place higher loads and greater demands on the highway system. The tire excise tax was 15 cents per pound for tires weighing over 40 to 70 pounds; $4.50 plus 30 cents per pound over 70 to 90 pounds; and $10.50 plus 50 cents per pound over 90 pounds.

2.6.3 Expenditures

2.6.3.1 Expenditures of State Funds – During the study period, an average of $172,974,000 per year of state funds were spent by MDT. A breakdown of these expenditures by type of activity is presented in Table 2.6.3.1-1. Ninety-seven percent of these expenditures were directly for state highway related purposes in the areas of construction, maintenance, and operation. The remaining 3 percent of MDT's expenditures consisted of money spent on the purchase of roadway materials for which MDT was reimbursed and fiscal adjustments to the annual cash flow.

The largest category of state expense was construction, which accounted for 40 percent of state expenditures on the system (in-house preconstruction plus construction project costs). A breakdown of construction project expenditures by specific activity is presented in Table 2.6.3.1-2. From a cost perspective, the greatest level of expenditure activity was on pavement

Table 2.6.3.1-1 Summary of MDT Expenditures of State Funds

Expenditure Type	Activity	Average Annual Expenditure ($1000s)	Percent of Expenditures within Each Type	Percent of All Expenditures
Direct Highway	General Operations	16,376	6	
	Pre-Construction	9,153	6	
	Construction	57,800	34	
	Maintenance	62,098	37	
	Dept. of Justice	16,247	10	
	Bond Interest	5,277	3	
	Miscellaneous	746	2	
Sub-total, Direct Highway		**167,698**	**100**	**97**
Non-Direct Highway	Purchase of Materials	**6,887**	**100**	**4**
Accounting Adjustments	-	**(1,611)**	**100**	**(1)**
Grand Total		**172,974**	**-**	**100**

Table 2.6.3.1-2 Summary of MDT Expenditures of State Funds on Construction

Activity	Average Annual Expenditures	
	Dollars (1000s)	Percent
Contract Administration	5,225	9
Grading and drainage	5,060	9
Roadway, Reconstruct and New	3,791	7
Roadway, Overlay	33,631	58
Bridge Structures	2,402	4
Traffic	6,857	12
Miscellaneous	834	1
Total	**57,800**	**100**

overlays, which accounted for 58 percent of all construction costs. Each of the other categories of construction expenditure individually accounted for less than 15 percent of all state construction costs. These activities included contract administration, grading and drainage related activities, work on roadside items, installation of traffic control items, traffic control on projects, bridge construction, construction of non-bridge structures, and roadway construction/reconstruction work.

State expenditures on highway maintenance accounted for 37 percent of all state highway expenditures. Maintenance expenditures by activity type are summarized in Table 2.6.3.1-2. As

observed for construction expenditures, the highest maintenance expenditures (42 percent of all maintenance funds) were on pavement related activities such as placing seal coats and chip seals, pothole repair, etc. Pavement expenditures were closely followed by winter maintenance expenditures on items such as sanding and de-icing (26 percent) and by expenditures on safety appurtenances such as striping (19 percent). All other maintenance activities collectively accounted for less than 13 percent of all maintenance expenditures.

Table 2.6.3.1-3 Summary of MDT Expenditures of State Funds on Maintenance

Activity	Average Annual Expenditures	
	Dollars (1000s)	Percent
Roadway	26,224	42
Roadside	4,040	7
Drainage	1,356	2
Bridges	249	0
Traffic Safety	11,534	19
Winter Maintenance	16,235	26
Materials	2,312	4
General Operations	149	0
Total	**62,098**	**100**

Remaining expenditures of state monies on the highway system included funding for the State Highway Patrol (10 percent (through the Department of Justice)), general operations (9 percent), bond interest (3 percent), and miscellaneous activities (2 percent).

Note that the state sold bonds specifically to finance highway construction activities prior to the study period. The proceeds from these bonds, and the principal payments made in retiring these bonds, were assumed to balance, and they are not explicitly included in the cash flow information presented above. The bond interest, however, is an added cost that must be covered by highway revenues.

2.6.3.2 Expenditures of Federal Funds – Federal highway trust fund monies, averaging $153,144,000 per year, were used almost exclusively for highway construction activities. An estimated ninety-seven percent of trust fund monies (average of $148,550,000 per year) were spent on these activities.

3. REVENUE ALLOCATION

3.1 GENERAL REMARKS

The objective of the revenue allocation process was to assign the revenue used to fund the highway system back to the specific vehicles from which it was collected. This apparently simple task was complicated by the fact that the information typically available on highway revenue consisted only of the net revenue collected by each type of tax or fee. Thus, the revenue allocation process consisted of estimating the amount of revenue that came from (or was associated with) each vehicle configuration based on:

a) the limited information that was available from various government agencies on the specific sources of highway revenue by vehicle type, and
b) knowledge of the basis upon which various taxes and fees were levied, coupled with information on the underlying parameters that determined the amount of tax collected from each specific type of vehicle (e.g., inferring fuel tax paid from the fuel tax rate, miles driven and fuel consumption rate).

Some vehicles were exempt from some or all types of highway taxes and fees. Such vehicles included, for example, government vehicles and some farm vehicles. With the exception of the exemptions for "off- road" vehicle use and public bus operation, tax and fee exemptions were ignored in this study. The percentage of exempt and reduced fee paying vehicles was believed to be small in magnitude (less than 5 percent of all vehicles) and uniformly distributed across all vehicle classes. Thus, ignoring exempt vehicles was expected to have only a limited impact on the over-all study results. Furthermore, exempt vehicles could not be distinguished from full fee paying vehicles in the traffic data. Only the "BUS" vehicle class was expected to have a large percentage of fee-exempt vehicles (notably, school busses), and these vehicles were clearly identified in the traffic data. Thus, it was possible to account for the fee exempt status of this group of vehicles in the revenue allocation process.

3.2 STATE REVENUE ALLOCATION

3.2.1 General Remarks

Passenger vehicles, single units, and combination vehicles were found to be responsible for 64, 10, and 26 percent of state highway revenues, respectively, over the three year study period. Recall that state revenues used for highway purposes consisted of fuel taxes (81%), weight fees (12%), sales tax on the purchase of new vehicles (5%), and miscellaneous revenue (2%). The allocation of this revenue by vehicle class is summarized in Table 3.2.1-1.

3.2.2 Fuel Taxes (81% of state revenue used for highway purposes)

As might be expected, personal vehicles contributed most of the gasoline tax revenue (91 percent), while combination vehicles were responsible for most of the diesel tax revenue (83 percent). Gasoline and diesel fuel tax revenue was allocated to the various configurations from which it was collected based on estimates of:

a) the percentage of vehicles within the configuration that utilized gasoline versus diesel fuel,
b) average fuel consumption across all vehicles of that configuration, and
c) the distance traveled by vehicles of that configuration.

The fraction of the fuel tax revenue assigned to each vehicle configuration was calculated by first estimating the total gallons of fuel used by each configuration:

$$\text{Estimated fuel used} = \frac{\text{(Distance traveled) * (Percent of travel by fuel type)}}{\text{Fuel consumption rate}}$$

These values were then divided by the estimated total amount of fuel used across all configurations to obtain that fraction of the fuel tax revenue to be allocated to each configuration,

$$\text{Fraction of fuel revenue by vehicle class} = \frac{\text{Estimated volume of fuel used by the vehicle class}}{\text{Estimated volume of fuel used by all vehicles}}$$

Information on the split in fuel types used by various vehicle configurations was obtained from the Montana data collected for the federal Truck Inventory and Use Survey (TIUS) (U.S. Department of Commerce, 1995). Average fuel consumption rates were estimated from the

Table 3.2.1-1 Allocation of State Revenue Used on the State Highway System

Vehicle Class	Revenue Source											
	Gasoline Tax		Diesel Fuel		GVW Fees		New Vehicle Sales Tax		Other		All Revenues	
	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent
Auto	55,152	51.3	1,296	3.4	0	0.0	5,285	59.6	2,267	56.0	64,000	35.5
Pickup	43,055	40.0	2,066	5.3	2,803	13.2	3,330	37.6	1,262	31.2	52,516	29.1
Personal Vehicles	**98,207**	**91.3**	**3,362**	**8.7**	**2,803**	**13.2**	**8,615**	**97.2**	**3,529**	**87.2**	**116,516**	**64.6**
SU2	6,066	5.6	485	1.3	2,132	10.1	23	0.3	97	2.4	8,804	4.9
SU3	1,782	1.7	2,121	5.5	2,000	9.4	48	0.5	42	1.0	5,992	3.3
SU4+	46	0.0	423	1.1	344	1.6	17	0.2	5	0.1	834	0.5
BUS	365	0.3	121	0.3	12	0.1	3	0.0	17	0.4	519	0.3
Single Units	**8,259**	**7.7**	**3,150**	**8.1**	**4,487**	**21.2**	**91**	**1.0**	**161**	**4.0**	**16,148**	**9.0**
CS3	183	0.2	547	1.4	228	1.1	4	0.0	11	0.3	973	0.5
CS4	268	0.2	1,345	3.5	552	2.6	2	0.0	19	0.5	2,186	1.2
CS5	217	0.2	19,744	51.0	5,343	25.2	102	1.1	211	5.2	25,617	14.2
CS6	17	0.0	1,590	4.1	557	2.6	5	0.1	17	0.4	2,187	1.2
CS7+	1	0.0	48	0.1	44	0.2	2	0.0	1	0.0	95	0.1
CT4-	344	0.3	1,530	4.0	1,690	8.0	1	0.0	24	0.6	3,589	2.0
CT5	16	0.0	1,465	3.8	2,039	9.6	1	0.0	16	0.4	3,538	2.0
CT6+	10	0.0	885	2.3	1,158	5.5	1	0.0	9	0.2	2,063	1.1
DS5	5	0.0	446	1.2	108	0.5	0	0.0	4	0.1	563	0.3
DS6	5	0.0	439	1.1	146	0.7	0	0.0	4	0.1	594	0.3
DS7	22	0.0	1,997	5.2	1,048	4.9	19	0.2	20	0.5	3,107	1.7
DS8+	23	0.0	2,140	5.5	995	4.7	23	0.3	20	0.5	3,201	1.8
Combination Trucks	**1,111**	**1.0**	**32,177**	**83.2**	**13,908**	**65.6**	**161**	**1.8**	**357**	**8.8**	**47,713**	**26.5**
All Vehicles	**107,577**	**100.0**	**38,689**	**100.0**	**21,198**	**100.0**	**8,866**	**100.0**	**4,047**	**100.0**	**180,377**	**100.0**

Montana data collected for TIUS, from information presented in the Highway Statistics compiled each year by FHWA (1995, 1996, 1997), and from a variety of other sources (Stephens, Barth and Cloud, 1992; EPA, 1997). Annual vehicle miles of travel for each configuration was obtained from the traffic data provided by MDT.

3.2.3 Weight Fees (12% of state revenue used for highway purposes)

As might be expected, the majority of the weight fees collected by MDT were allocated back to combination vehicles (66 percent), which typically are assessed the largest fees on a per vehicle basis. None-the-less, a significant portion of the revenue from weight fees (13 percent) was allocated to personal vehicles (specifically, to pickups). While the weight fees paid on a per vehicle basis by light pickups were an order of magnitude lower than those paid by typical combination vehicles, significantly more light pickups were registered in the state than combination vehicles. Single units paid the remaining weight fees (21 percent). The information available from the Motor Carrier Services Division of MDT regarding GVW fees consisted of the amount collected by increment of registered gross vehicle weight by collection agency (i.e., the International Registration Plan (IRP), the motor vehicle offices in each county, or the Motor Carrier Services Division of MDT, itself). The revenue reported at each weight increment was subsequently allocated to the specific vehicle configurations expected to register at that gross weight level. These allocations were done based on recommendations from the Motor Carrier Services Division (Ala, 1999) and projections of vehicle use from weigh station and traffic data. In general, it was found that vehicles registered at the maximum allowable GVW for their configuration. Note that while the information available from MDT did not specifically identify weight fees collected from light trucks (pickups) as opposed to other vehicles, this information was available from the state Motor Vehicle Division of the Department Justice (1999a). The miscellaneous fees collected by the Motor Carrier Services division of MDT for special permits, fines, etc. were allocated to intermediate and combination vehicles based on VMT. This approach was consistent with the idea that the permits, fines, and misc. fees were generally leveled uniformly across commercial truck traffic.

3.2.4 New Vehicle Sales Tax (5% of state revenue for highway purposes)

Revenue from the new vehicle sales tax was approximately allocated to the vehicles from which it was collected. Allocation of this revenue is summarized in Table 3.2.1-1. Only limited information was available from MDT on the source of this revenue by vehicle configuration. The Motor Vehicle Division of the Department of Justice (1999b) did have some information regarding how this tax was collected, and they were able to sort the revenue for state fiscal year 1997 into broad categories by vehicle type and maximum gross weight. Notably, the revenue collected from the sales of automobiles and pickup trucks was clearly identified. This information, augmented as necessary by estimates of the number of vehicles of each configuration replaced each year, their cost, and the attendant sales tax paid, was used to develop allocation factors that were used across all years in the study period.

3.2.5 Remaining Revenue (2% of state revenue used for highway purposes)

The remaining revenue used to fund the state highway system (only 2 percent) consisted primarily of proceeds from the Coal Tax trust fund (1995 only). The Coal Tax trust related funds were allocated using VMT, based on the philosophy that the intent of the legislature in making this disbursement was to provide equal benefit to all highway users.

3.3 FEDERAL REVENUE ALLOCATION

3.3.1 General Remarks

Personal vehicles, single units, and combination trucks were responsible for 51, 10, and 40 percent, respectively, of the federal revenue attributable to Montana that was subsequently used to fund the highway system. Revenue allocation by broad vehicle class and individual vehicle configuration is summarized in Table 3.3.1-1. Federal revenue used on the highway system in Montana was derived from fuel taxes (82%), taxes on the sales of trucks and trailers (12%), the HVUT (5%), and taxes on truck tires (3%).

3.3.2 Fuel Taxes (82% of federal revenue from Montana used for highway purposes)

Federal fuel tax revenues attributable to Montana were allocated back to the vehicles from which they were collected using the same methodology described above for state fuel tax

Table 3.3.1-1 Allocation of Federal Revenue Used on the State Highway System

Vehicle Class	Revenue Source											
	Gasoline Tax		Special Fuel		Sales Tax		HVUT		Tire Tax		All Revenues	
	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent
Auto	24,698	51.3	877	3.4	0	0.0	0	0.0	0	0.0	25,575	28.1
Pickup	19,276	40.0	1,397	5.3	0	0.0	0	0.0	0	0.0	20,672	22.7
Personal Vehicles	**43,974**	**91.3**	**2,273**	**8.7**	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**46,248**	**50.9**
SU2	2,715	5.6	328	1.3	0	0.0	0	0.0	226	8.9	3,269	3.6
SU3	798	1.7	1,434	5.5	2,068	20.9	0	0.0	148	5.8	4,448	4.9
SU4+	20	0.0	286	1.1	298	3.0	13	0.3	21	0.8	638	0.7
BUS	163	0.3	82	0.3	0	0.0	0	0.0	0	0.0	245	0.3
Single Units	**3,697**	**7.7**	**2,130**	**8.1**	**2,366**	**23.9**	**13**	**0.3**	**395**	**15.5**	**8,601**	**9.5**
CS3	82	0.2	370	1.4	320	3.2	0	0.0	38	1.5	811	0.9
CS4	120	0.2	909	3.5	108	1.1	23	0.6	90	3.5	1,250	1.4
CS5	97	0.2	13,344	51.0	3,631	36.7	2,805	67.8	1,231	48.3	21,108	23.2
CS6	8	0.0	1,074	4.1	381	3.9	247	6.0	119	4.7	1,829	2.0
CS7+	0	0.0	33	0.1	11	0.1	41	1.0	5	0.2	90	0.1
CT4-	154	0.3	1,034	4.0	215	2.2	10	0.2	103	4.1	1,517	1.7
CT5	7	0.0	990	3.8	1,006	10.2	60	1.4	91	3.6	2,154	2.4
CT6+	4	0.0	598	2.3	517	5.2	72	1.7	63	2.5	1,254	1.4
DS5	2	0.0	301	1.2	111	1.1	13	0.3	26	1.0	453	0.5
DS6	2	0.0	297	1.1	108	1.1	21	0.5	31	1.2	458	0.5
DS7	10	0.0	1,350	5.2	486	4.9	463	11.2	164	6.5	2,474	2.7
DS8+	11	0.0	1,446	5.5	629	6.4	369	8.9	189	7.4	2,644	2.9
Combination Trucks	**498**	**1.0**	**21,747**	**83.2**	**7,524**	**76.1**	**4,122**	**99.7**	**2,151**	**84.5**	**36,042**	**39.7**
All Vehicles	**48,169**	**100.0**	**26,151**	**100.0**	**9,890**	**100.0**	**4,135**	**100.0**	**2,545**	**100.0**	**90,890**	**100.0**

revenues. The data used in this process consisted simply of the total fuel tax collected for gasoline and special fuels. All special fuel was treated as diesel fuel for these analyses. As observed for state fuel tax revenue, personal vehicles were found to be responsible for much of the gasoline based revenue (91 percent), while combination vehicles were responsible for most of the special fuels related revenue (83 percent). With respect to total fuel tax revenues (gasoline and diesel fuel combined), however, personal vehicles were found to be responsible for only 62 percent of this revenue at the federal level, compared to 69 percent of this revenue at the state level. This change in relative responsibility resulted primarily from the significantly higher tax charged on diesel fuel relative to gasoline at the federal level compared to the more uniform rate charged by the state. Consistent with this general situation, combination trucks were found to be responsible for 30 percent of all federal fuel tax revenue compared to 23 percent of state fuel tax revenue.

<u>3.3.3 Truck and Trailer Sales Tax</u> (12% of federal revenue from Montana targeted for highway purposes)

Twenty-four and seventy-six percent of the receipts from the federal truck and trailer sales tax were allocated, respectively, to single unit vehicles and combination trucks. No definitive information was found on the specific source by vehicle type of the revenue collected from this tax. This revenue was allocated based on estimates of the replacement rate and purchase price of each type of vehicle, and the subsequent tax that they would have paid. Note that to obtain an idea of replacement rates, further assumptions were made regarding the annual miles of travel and the service life of each vehicle configuration primarily from information from Highway Statistics (FHWA, 1995, 1996, 1997a), TIUS (Bureau of the Census, 1995), and truck dealerships. Based on the number of estimates involved in the process outlined above, and the limited information and resource available to formulate these estimates, the results of this analysis are somewhat uncertain, and this allocation may merit further investigation.

<u>3.3.4 HVUT</u> (5% of federal revenue from Montana targeted for highway purposes)

With the exception of a small allocation to 4 axle single units, the federal HVUT revenue was allocated to combination trucks. Within this group of vehicles (that is, vehicles with a gross vehicle weight in excess of 55,000 pounds), the HVUT revenue was allocated back

to the vehicles from which it was collected by multiplying the number of vehicles expected to register at each weight by the fee at that weight. The information available on vehicle configurations and registered weights that was used in allocating state GVW fees back to the vehicles that paid them was used in this process.

3.3.5 Tire Tax (3% of federal revenue from Montana targeted for highway purposes)

Tire tax revenue was allocated to 2 axle, 6 tire and larger vehicles based on AMT. In following this allocation approach, the implicit assumption was made that tire weights are uniform across all vehicle classes, and that the number of tires replaced per vehicle is proportional to the number of axles on the vehicle and the distance driven.

3.4 COMBINED FEDERAL AND STATE REVENUE ALLOCATION

Combined state and federal revenues by broad vehicle category and individual vehicle class are reported in Table 3.4-1. These values were calculated as the simple sum of the results of the state and federal allocations performed above. The proportion of total revenue derived from state sources gradually and steadily decreased with increasing vehicle size. This trend was attributed to the more progressive nature of the federal highway fee structure versus that of the state with respect to assessing fees on heavier vehicles. The federal fee structure:

a) taxed diesel fuel (used extensively by heavier vehicles) at a higher rate than gasoline (used extensively by lighter vehicles),
b) only charged intermediate and heavy vehicles the 12 percent sales tax on their purchase price, and
c) only levied weight related fees on the heaviest vehicles (the HVUT).

Note, however, that for the heaviest vehicles, the federal weight related tax (the HVUT) levels off at a constant amount for all vehicles over 75,000 pounds, while Montana's weight related fees continue to increase above this point in direct proportion to gross vehicle weight.

Table 3.4-1 Allocation of Combined State and Federal Revenues

Vehicle Class	Combined State and Federal Revenues		Split State versus Federal Funds	
	Dollars (1000s)	Percent	Percent State	Percent Federal
Auto	89,575	33	71	29
Pickup	73,188	27	72	28
Personal Vehicles	**162,763**	**60**	**72**	**28**
SU2	12,073	4	73	27
SU3	10,440	4	57	43
SU4+	1,472	1	57	43
BUS	764	0	68	32
Single Units	**24,749**	**9**	**65**	**35**
CS3	1,784	1	55	45
CS4	3,436	1	64	36
CS5	46,725	17	55	45
CS6	4,016	1	54	46
CS7+	185	0	51	49
CT4-	5,106	2	70	30
CT5	5,692	2	62	38
CT6+	3,317	1	62	38
DS5	1,017	0	55	45
DS6	1,052	0	56	44
DS7	5,581	2	56	44
DS8+	5,845	2	55	45
Combination Trucks	**83,755**	**31**	**57**	**43**
All Vehicles	**271,267**	**100**	**66**	**34**

3.5 REVENUE PER MILE OF TRAVEL

The results of the revenue allocation process were used to determine the revenue per mile of travel for each vehicle class. State, federal, and combined revenue per unit distance traveled is reported in Table 3.5-1. These values provide another perspective on user revenues, and they were used later in this study to assess the sufficiency of user payments to cover the costs of providing them with highway service. In all cases, revenue generally increased with configuration size, as would be expected from fee systems designed to at least broadly reflect vehicle cost responsibility. State revenue ranged from a low of 1.62 cents per mile of travel for

Table 3.5-1 Revenue per Vehicle Mile of Travel

Vehicle	Revenue, cents/mile		
	State	Federal	Combined
Auto	1.62	0.65	2.27
Pickup	2.40	0.94	3.34
Personal Vehicles	**1.90**	**0.75**	**2.65**
SU2	5.22	1.94	7.16
SU3	8.17	6.06	14.23
SU4+	10.52	8.05	18.57
BUS	1.71	0.81	2.51
Single Units	**5.76**	**3.07**	**8.83**
CS3	5.09	4.24	9.34
CS4	6.52	3.72	10.24
CS5	6.97	5.74	12.71
CS6	7.39	6.18	13.57
CS7+	10.61	9.99	20.60
CT4-	8.74	3.69	12.43
CT5	12.97	7.90	20.87
CT6+	13.27	8.07	21.34
DS5	7.21	5.80	13.01
DS6	7.71	5.95	13.66
DS7	8.86	7.05	15.91
DS8+	9.07	7.49	16.56
Combination Trucks	**7.69**	**5.81**	**13.50**
All Vehicles	**2.57**	**1.29**	**3.86**

automobiles to a high of 13.27 cents per mile of travel for 6 or more axle, truck and trailer vehicles. Revenue per mile of travel was generally higher for truck and truck and trailer combinations relative to tractor, semi-trailer combinations registered at approximately the same weight. Truck and truck and trailer combinations were generally driven fewer miles per year relative to tractor, semi-trailer vehicles, and thus their basic GVW weight fees (levied independent of miles driven) increased their revenue as a function of vehicle miles traveled relative to tractor, semi-trailers.

Federal revenue ranged from a low of 0.65 cents per mile of travel for automobiles to a high of 9.99 cents per mile for tractor, semi-trailer trucks with 7 or more axles. Federal revenues per mile of travel were, in general, lower than state revenues, primarily due to the

relative magnitudes of the fuel tax rates at the federal and state levels. The trends observed in state revenue per vehicle mile of travel commented on above were also seen in federal revenue per vehicle mile of travel. Such a result was expected, as both levels of government levied similar types of taxes.

4. EXPENDITURE ALLOCATION

4.1 GENERAL REMARKS

Expenditures on various activities were allocated to each class of vehicle in accordance with the costs occasioned in providing that class of vehicle with highway service. General allocation strategies by type/category of expenditure are summarized in Table 4.1-1. Different types of cost allocators were used on various expenditure items, depending on the activity involved and the type of vehicle demand being addressed. Activity costs that were independent of the specific vehicles involved were generally allocated based on VMT. Activity costs that were influenced by specific attributes of the vehicles involved were allocated, as possible, based on those attributes.

Table 4.1-1 Overview of Cost Allocation Strategies

Category of Expenditure	Allocation Strategy
General Operations, including GVW Operations	Allocated as common cost (VMT); except for cost of GVW Operations, which was allocated to single units and larger based on AMT
Construction In-house pre-construction	Allocated using factors developed from analysis of construction project costs
Construction projects	Basic facility cost shared as common cost, remaining costs allocated based on vehicle characteristics that influenced them
Maintenance	Cost of individual activities allocated based on vehicle characteristics that influenced them
Dept. of Justice	Allocated as common cost (VMT)
Bond Interest	Allocated as construction expenditures were allocated
Miscellaneous	Review individual types of activities and allocate their cost based on vehicle characteristics that influence them

4.2 EXPENDITURE OF STATE FUNDS

4.2.1 General Remarks

Personal use vehicles, single units, and combination trucks were found to be responsible for 67, 8, and 25 percent of state expenditures on the highway system over the 3 year study period. State funds were used for, general operations (10 %), construction (40 %), maintenance (37 %), operation of the highway patrol (10 %), and other miscellaneous activities (3 %). Allocation of these expenditures by vehicle class is summarized in Table 4.2.1-1.

4.2.2 General Operations (10 % of state funds expended)

Sixty-five, seven, and twenty-eight percent of MDT's general operating costs were allocated to personal use vehicles, single units, and combination trucks, respectively. As the title implies, this category of costs covers expenditures related to the general operation of MDT and includes the costs of the Director's Office, general administration, personnel, accounting, planning, program development, building construction, building maintenance, etc. With the exception of the operation of the Motor Carrier Services Division, the costs of these activities were allocated to all users as common costs based on VMT. Operation of the Motor Carrier Services Division of MDT was allocated to single unit trucks (2 axle, 6 tire and larger) and combination trucks based on AMT. The Motor Carrier Services Division of MDT is responsible for administering a variety of vehicle related fee programs enacted by the state of Montana. Activities of the division include the assessment and collection of gross weight fees, enforcement of vehicle weight and size restrictions (including weigh station operation), issuance of special overweight and oversize permits, etc. Most of the work done by the division is related to commercial vehicles, work on matters related to pickup trucks is estimated to account for less than 1/2 percent of division expenditures (Stephens, Barth, and Cloud, 1992). AMT was selected as an appropriate cost allocator, as many fee and enforcement activities were axle, rather than vehicle, related.

4.2.3 Construction (40 % of state funds expended)

Expenditures on highway construction and maintenance amounted to 40 percent of the state monies spent over the study period. MDT clearly differentiates between construction and

Table 4.2.1-1 Allocation of State Funds Spent on the Highway System

Vehicle Class	Average Annual Expenditure													
	Construction		Maintenance		Highway Patrol		General Ops		Debt Service		Other		All	
	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent
Auto	22,198	33.2	29,083	46.8	9,103	56.0	6,824	41.7	1,756	33.3	418	56.0	69,381	41.4
Pickup	15,015	22.4	17,664	28.4	5,063	31.2	3,795	23.2	1,197	22.7	233	31.2	42,968	25.6
Personal Veh	**37,213**	**55.6**	**46,747**	**75.3**	**14,166**	**87.2**	**10,619**	**64.8**	**2,953**	**56.0**	**651**	**87.2**	**112,349**	**67.0**
SU2	4,650	6.9	2,213	3.6	390	2.4	662	4.0	383	7.3	18	2.4	8,316	5.0
SU3	1,419	2.1	933	1.5	170	1.0	368	2.2	109	2.1	8	1.0	3,007	1.8
SU4+	184	0.3	102	0.2	18	0.1	48	0.3	10	0.2	1	0.1	364	0.2
BUS	614	0.9	334	0.5	70	0.4	83	0.5	51	1.0	3	0.4	1,156	0.7
Single Units	**6,868**	**10.3**	**3,582**	**5.8**	**648**	**4.0**	**1,162**	**7.1**	**553**	**10.5**	**30**	**4.0**	**12,843**	**7.7**
CS3	514	0.8	315	0.5	44	0.3	96	0.6	42	0.8	2	0.3	1,013	0.6
CS4	1,057	1.6	554	0.9	78	0.5	205	1.3	86	1.6	4	0.5	1,983	1.2
CS5	11,464	17.1	6,204	10.0	849	5.2	2,652	16.2	899	17.0	39	5.2	22,107	13.2
CS6	1,056	1.6	631	1.0	68	0.4	246	1.5	82	1.5	3	0.4	2,086	1.2
CS7+	51	0.1	21	0.0	2	0.0	9	0.1	2	0.0	0	0.0	85	0.1
CT4-	776	1.2	604	1.0	95	0.6	240	1.5	59	1.1	4	0.6	1,778	1.1
CT5	2,635	3.9	876	1.4	63	0.4	197	1.2	198	3.7	3	0.4	3,971	2.4
CT6+	759	1.1	385	0.6	36	0.2	129	0.8	60	1.1	2	0.2	1,371	0.8
DS5	170	0.3	115	0.2	18	0.1	56	0.3	14	0.3	1	0.1	373	0.2
DS6	226	0.3	141	0.2	18	0.1	64	0.4	17	0.3	1	0.1	467	0.3
DS7	2,053	3.1	963	1.6	81	0.5	330	2.0	157	3.0	4	0.5	3,588	2.1
DS8+	2,110	3.2	962	1.5	81	0.5	370	2.3	156	3.0	4	0.5	3,683	2.2
Comb. Trks	**22,872**	**34.2**	**11,769**	**19.0**	**1,433**	**8.8**	**4,596**	**28.1**	**1,771**	**33.6**	**66**	**8.8**	**42,506**	**25.3**
All Vehicles	**66,952**	**100**	**62,098**	**100**	**16,247**	**100**	**16,377**	**100**	**5,277**	**100**	**746**	**100**	**167,697**	**100.0**

maintenance activity costs for administrative purposes, and this same division in activities was followed in this study. In general, construction was defined as activities that resulted in a long-term (more than 5 years) improvement in the level of service provided by a highway facility. Maintenance tasks were defined as those activities related to simply maintaining the level of service provided by an existing facility over the short term (5 years or less).

Personal use vehicles, single units, and combination trucks were allocated 56, 10, and 34 percent of construction costs, respectively, over the study period. To allocate construction expenditures, a cost analysis was performed of all the construction projects let during the study period. Costs itemized in contract documents were grouped into the activity categories listed in Table 4.2.3-1. Annual expenditures on each activity were assigned to the various vehicle classes using the allocation strategies presented in Table 4.2.3-1. Note that activity costs were tabulated and allocated independently for each unit of the highway system. Thus, any differences in expenditure and use patterns on the various units of the federal aid system are accurately represented in these results. The total expenditure on each class of vehicle was calculated by summing the costs allocated to each class for each activity across all systems.

These analyses were performed using "as-bid" prices rather than actual construction costs. For this and other reasons, the sum of the expenditures assigned to each vehicle class nominally differed from the reported total construction costs. Therefore, the results of these analyses were used to calculate cost allocators to be used in assigning the actual construction costs to each vehicle class. These allocators were calculated as the ratio of the cost assigned to each vehicle class divided by the total assigned costs.

Reviewing Table 4.2.3-1, the costs of many of the construction activities were simply allocated based on VMT. The costs of all such activities were judged to be independent of the characteristics of the specific vehicles that used the highway. Activities related to paving and structures were allocated based on an engineering analysis of the specific demands various vehicles place on these elements of the highway system. Each construction activity is briefly described in the following paragraphs with comments, as appropriate, on the attendant cost allocator used. Note that construction engineering costs were prorated across all activities.

Across all construction cost allocations, the decision was made that lane width above and beyond that required for safe operation of the narrowest vehicles would not be incrementally allocated to wider vehicles. This decision was based, in part, on the observation that even

Table 4.2.3-1 Allocation of Construction Costs from Projects, State Funds

Activity	Percent of All Costs	Allocator
Contract Administration	9	Common cost (VMT)
Grading and Drainage	9	Common cost (VMT)
Pavement		
New Construction/Major Rehab Sub-Surface/Base Sub-Surface/Base, Treatments New Pavement	7	Basic facility cost, VMT to all; Remaining cost, ESAL-M to all; Basic facility for basic vehicle, environment, and occasional heavy truck; Widening projects by PCE
Overlay Surface Prep, Existing Roadway Overlay	58	Basic overlay cost, VMT to all; Remaining cost, ESAL-M to all; Thin overlays, increase load related cost assigned based on expected life of overlay under actual traffic stream versus life under basic vehicles only
Bridges	3	New and replacement due to functional deficiency: Basic facility cost, VMT to all, remaining cost, based on structural demand; Replacement due to structural deficiency: Basic facility cost, VMT to all heavy vehicles, remaining cost, based on structural demand
Traffic (Guard rails, signs, traffic control)	12	Common cost (VMT)
Miscellaneous	1	Allocated based on nature of individual activities
All	100	-

personal vehicles realize secondary benefits from increased lane width (e.g., driver comfort and vehicle safety). Therefore, whether lane widths would be substantially decreased in the absence of any large vehicles in the traffic stream is uncertain. In particular, Montana has several stretches of highway with “wide” lanes but little or no shoulder, in which the “wide” lanes are important to the safety of all users. Note that in the recent federal cost allocation study, lane width requirements were considered to vary for different vehicles, and attendant lane width costs were not allocated as a common cost.

Following a similar philosophy to that mentioned above for lane widths, the judgement was made that while climbing lanes on two lane highways are used by passenger vehicles to pass heavy vehicles, they more generically are used by passenger and other vehicles to pass any slow moving vehicle, light or heavy. Once again, whether climbing lanes would be eliminated if heavy vehicles were absent in the traffic stream is uncertain. Thus, the decision was made to treat the expense of climbing lanes like any roadway cost, with non-load related demands allocated by VMT and load demands allocated by ESAL-M across all vehicles in the traffic stream.

4.2.3.1 Contract Administration - As indicated by the title, this activity consisted of the administrative tasks associated with conducting a construction project. This cost was shared between vehicles based on VMT.

4.2.3.2 Grading and Drainage - This category of activities covered construction site work, exclusive of placing the base and the wearing surface (pavement). Major activities in this category of expenditures included (a) surveying, clearing, and grading the roadway, (b) excavating, placing, and backfilling drains and culverts, (c) constructing embankments and retaining walls, and (d) relocating storm drains and water and sewer lines. The costs of all these activities were generally allocated based on VMT. Once again, in some cost allocation studies, part of the site preparation costs are allocated based on vehicle width, under the premise that wider vehicles require a wider road and right of way. In this study, as discussed above, the full lane width was allocated as a common cost across all vehicles. Costs associated with providing vertical grades that can be reasonably traversed by heavy vehicles have also been allocated in some studies based on characteristics related to these vehicles. In the absence of detailed

information on vehicle climbing performance on vertical grades, these costs were allocated as common costs in this study.

4.2.3.3 Roadway – For new construction and major reconstruction, roadway activities consisted of sub-surface preparation and placement of the base and wearing surface. For overlay projects, roadway costs consisted of surface preparation and placement of the running surface. Part of the cost of these tasks was allocated using VMT, while the remainder was allocated using ESAL-M.

Roadways deteriorate due to traffic loads and weathering/aging processes. From a cost allocation perspective:

1) fixed costs involved in constructing the roadway should be shared by the various classes as common costs. Such costs, including equipment mobilization and other items, are clearly independent of the specific vehicles involved.
2) costs associated with vehicle related deterioration of the roadway should be allocated based on the physical demand various vehicles place on the roadway. These demands will generally determine the thickness of the base and wearing surface. To design the base and wearing surface, these demands are quantified in terms of total expected ESALs, as previously discussed. (Note that the width of the wearing surface, as it is related to the width of the vehicles being served, was eliminated from consideration for reasons previously discussed.)
3) costs associated with weathering and aging related deterioration should be allocated as common costs. These costs can be considered independent of vehicle configuration.

Note that despite the manner in which they are discussed above, load and environmental factors interact in producing pavement deterioration, although this interaction is not always well modeled in the cost allocation process.

In light of the above considerations, the roadway costs for major construction/rehabilitation projects were divided into two components, namely, a) the cost of a basic facility with a 20 year design life to resist weathering and aging related deterioration and to carry predominantly basic vehicle traffic and an occasional heavy truck, and b) the additional cost of providing a facility to carry the complete traffic stream for a 20 year design life. The cost of the basic facility was allocated to all vehicles as a common cost using VMT. The additional

cost of the full facility to carry the complete traffic stream was allocated based on the relative pavement demands of the various vehicle configurations that use the system. This basic methodology has been used in many cost allocation studies.

The measure of pavement demand used in this study for all pavement activities was ESAL-M of travel. While this approach historically has been used in pavement allocation analyses, a new pavement model was developed and used in the recent federal cost allocation study for allocating the costs of pavement preservation activities. This model, referred to as the nationwide pavement cost model (NAPCOM), utilizes a mechanistic model to determine the physical response of pavements under vehicle loads (FHWA, 1997), which are in turn related to pavement distress. The limited comparisons that could be made in this study between these approaches to pavement cost allocation suggested that similar results were obtained from both approaches for "high" traffic volume roadways, but that the federal approach assigned a higher percentage of costs as load versus non-load related effects on "low" traffic volume roadways (see Section 6.4 of this report).

To implement the pavement cost allocation process used in this study, the MDT Materials Bureau designed basic facilities for each district in the state highway system to carry the average traffic observed on each unit of the system (assuming all vehicles were basic vehicles). In designing these basic facilities, the thickness of the running surface was held constant at 1.8 inches (the minimum thickness that presently can be placed) while the base thickness was varied from 4 inches to 18.5 inches in response to changing subgrade conditions and vehicle loads. To simplify the allocation process, a single basic facility was developed for use across the entire state for each unit of the federal aid system. These facilities were determined by averaging the base thicknesses required in each district weighted by the miles of highway of that type in the district. Costs for the minimum facilities were developed for each study year from information provided by MDT. For all reconstruction projects, the estimated cost of the basic facility was subtracted from the reported cost of roadway construction activities to determine that portion of the costs to be allocated based on ESAL-M.

The costs of major overlay projects were allocated to the various classes of highway users in a similar fashion as roadway reconstruction and rehabilitation projects. The cost of a basic overlay was allocated to all users based on VMT while the costs of any additional thickness of overlay was allocated based on ESAL-M. While a basic overlay of 1 inch was theoretically

adequate in all cases, the minimum thickness of overlay that could be practically placed was 1.8 inches.

The costs of thin pavement overlay projects were allocated to various vehicle configurations based on ESAL-M and the expected service life of the overlay. MDT generally used thin overlays to remediate load damage related to rutting and distortion of the drainage profile of otherwise sound roadways (Gilmore, 1999). These thin overlays resemble basic facilities, and they were predicted to offer 20 to 25 years of useful life under only personal vehicle demands. These predictions were made using an AASHTO ESAL performance model calibrated to actual experience in Montana (Stephens, et al, 1996). The predicted life of these overlays under the actual traffic stream they carry, however, ranged from only 5 to18 years, depending on the system and traffic stream being served. Note that these predictions of service life were judged by MDT to be consistent with the observed performance of actual thin overlays (Clark, 1999). The reduction in expected service life of the roadways under passenger vehicles versus the complete traffic stream was attributed to load related effects. Thus, the proportion of the total cost of thin overlay projects allocated based on load effects (using ESAL-M) was increased in direct proportion to the predicted reduction in service life of the overlay under the actual traffic stream.

The percentage of paving costs allocated using the above outlined procedure as load and non-related is summarized in Table 4.2.3.3-1. Load related costs ranged from 90 percent on the interstate system down to 52 percent on the secondary system, with the percent of load related costs varying in approximate proportion to the average volume of traffic carried on each element of the system. Surveys conducted in other cost allocation studies and guides (Oregon DOT, 1986; Urban Institute, et al, 1990) found that the relative amount of pavement maintenance costs allocated based on load effects (generally quantified in ESAL-M) ranged from 54 to 98 percent (see Table 4.2.3.3-2). Note that many of these estimates were based on expert opinion, rather than rigorous tests, and that they do refer to maintenance as opposed to construction. None-the-less, the proportions of pavement cost responsibility reported in these studies for the various elements of the highway system were generally consistent with those found in this study.

Table 4.2.3.3-1 Proportion of Overlay Costs Allocated as Load Related

System	Average Daily Traffic	Percent of Overlay Costs Allocated as Load Related
Interstate	5,179	90
NHS	2,261	71
Primary	1,067	72
Secondary	375	52
Urban	5,982	90

Table 4.2.3.3-2 Weathering/Aging and Traffic Related Deterioration of Highways

Study	Percent of Pavement Maintenance Costs Allocated Based on ESAL-M
Indiana (1984)	
Northern	66-87
Southern	70-98
Iowa (1983)	
Interstate	90
Surfaced	80
Unsurfaced	50
Maryland (1982)	75
Nevada (1984)	75
Oregon (1980)	90
Vermont (1990)	73
Virginia (1980)	
Interstate	77
Primary	66
Secondary	54

Source: Surveys of maintenance cost allocation given in: Urban Institute, et al (1990), Oregon DOT (1986)

A proportion of the total project cost on jobs in which lanes were added to the roadway was allocated using PCE weighted VMT. PCE (passenger car equivalent) is a measure of the relative influence of a vehicle on traffic operations compared to that of a passenger car. PCE

magnitudes reflect, among other things, the ability of a vehicle to accelerate, and they vary as a function of a variety of parameters, including vehicle weight to power ratio, highway geometrics (length of grade, steepness of grade, number of lanes), and composition of the traffic stream (e.g., percent trucks) (AASHTO, 1990). Highway capacity at a given level of service is inversely related to the product of the proportion of trucks in the traffic stream multiplied by their PCE value. Thus, highway expenditures related to service/capacity issues (such as lane additions) can reasonably be allocated based on PCE and the percent of trucks in the traffic stream, and a commonly used allocator is PCE weighted VMT.

4.2.3.4 Bridges - The bridge work done during the study period consisted almost exclusively of bridge construction work, as opposed to bridge repair work. The manner in which bridge construction costs were allocated was related to the underlying motivation for the bridge work. In this regard, projects were classified as replacement due to significant structural deficiencies, replacement due to structural and functional deficiencies, replacement due to functional deficiencies, and new construction. The proportion of projects falling in each category is listed in Table 4.2.3.4-1.

The costs of bridges replaced due to obvious structural deficiencies (many of which also had functional deficiencies) were allocated to those vehicle configurations whose demands

Table 4.2.3.4-1 Motivation for Bridge Construction Work

Motivation for Bridge Work	% of All Projects	Allocation Strategy
New	10	Cost of basic facility shared by all based on VMT, additional cost shared based on vehicle's level of structural demand
Significant structural deficiencies	42	Cost of basic facility shared by all vehicles with structural demands above load rating of current structure, additional cost shared based on vehicle's level of structural demand
Structural and functional deficiencies	23	Same as new
Functional deficiencies	25	Same as new
Total	**100**	

exceeded the capacity of the existing structure. Within this subgroup of vehicles, costs were allocated using a basic facility approach, whereby the cost of the structure required to support the least demanding vehicle in the group was shared across all vehicles in the group (using relative VMT by configuration).

Costs above the basic facility cost were incrementally shared by each vehicle configuration that subsequently required that increment in bridge capacity. Costs of bridges that were replaced to address functional concerns and costs of new bridge construction were allocated across all vehicles in the traffic stream using the basic facility approach. Once again, the cost of the basic facility necessary to support the least demanding vehicles in the traffic stream (in this case, passenger vehicles) was shared across all vehicles based on VMT. The costs of subsequent incremental increases in cost were shared by those subgroups of vehicles that required that capacity.

For the calculations above, demand was measured in terms of the maximum bending moment generated in the bridge by each vehicle configuration operating at their maximum gross weight. Engineering demands bridges are designed to resist include bending moment, shear, and deflection. Of these demands, bending moment generally controls the capacity of the primary bridge beams (Stephens, et al, 1996).

4.2.3.5 Structures (non-bridge) - Grouped into this category of construction was any structural work done outside of major bridge construction. With the exception of weigh station work, expenditures in this category were allocated across all vehicle configurations based on TMT (ton miles of travel). Weigh station construction work was allocated across all non-passenger vehicles based on TMT.

4.2.3.6 Roadside - Activities in this category were primarily "landscaping" related, e.g., sprinkler systems, sodding, seeding, wetlands development, etc. Costs of these activities were VMT allocated.

4.2.3.7 Traffic - Activities in this category were related to controlling and directing vehicles, and include placing signs, guardrails, signals, etc. Costs of these activities were allocated based on VMT.

4.2.3.8 Inhouse Pre-Construction Activities - The cost of MDT's pre-construction activities was assigned to the various vehicle configurations based on the net allocation of the funds spent on the actual construction activities described above. The specific activities grouped in this

category include: engineering administration; project management; right-of-way procurement; and roadway, bridge, and traffic engineering. While the level of effort required to complete these tasks may to a large extent be independent of the specific vehicles to be served, these tasks are only being performed in response to some identified construction need. Thus, the decision was made to allocate these costs consistent with the allocation of the costs from the construction activities which they support. Note that in some cost allocation studies, part of the right-of-way costs are allocated based on vehicle width, with the idea that wider vehicles require wider lanes and subsequently wider right-of-ways than basic vehicles. In this study, however, it was decided that all vehicles share benefits from wide travel lanes, and thus VMT was an appropriate cost allocator.

4.2.4 Maintenance (37% of state funds expended)

Basic, intermediate, and heavy vehicles were allocated 75, 6, and 19 percent, respectively, of the maintenance expenditures on the highway system during the study period. These costs were primarily allocated using VMT and ESAL-M, based on the specific tasks being considered. The categories of maintenance activities used in this study are listed in Table 4.2.4-1. Annual expenditures on each type of activity were obtained by analyzing maintenance account information provided by MDT (1998). The expenditures on each activity were assigned to the various vehicle classes using the allocation strategies indicated in Table 4.2.4-1. Activity costs were tabulated and allocated independently on each of the major units of the system.

4.2.4.1 Roadway - Maintenance activities on the roadway primarily consisted of patching and sealing the wearing surface and the placement of thin overlays. Deterioration of seal coats was judged to be related to the number of axle passages over the roadway, and these costs were allocated to all vehicles based on AMT. The costs of patching and overlay activities were divided into two fractions, namely, load related and non-load costs. The proportion of the total costs assigned to each category was simply set at the proportion of paving construction costs found to be load related versus non-load related, as listed in Table 4.2.3.3-3. The non-load related portion of the cost was allocated as a common cost using VMT. The costs of load related deterioration were allocated based on the demand specific vehicles placed on the roadway as measured in ESAL-M.

Table 4.2.4-1 Allocation of Maintenance Expenditures, State Funds

Activity	Percent of All Costs	Allocator
Roadway Paving	42	Paving split into load and non-load related costs using factors developed from construction analysis (Table 4.2.3.3-1); Non-load related by VMT, Load related by ESAL-M
Seal coats		AMT
Roadside	7	Common cost (VMT)
Drainage	2	Common cost (VMT)
Traffic safety (striping, etc.)	19	Striping by AMT; other activities as common costs (VMT)
Winter maintenance (snow plowing, sanding, etc.)	26	Sanding by AMT; other activities as common costs (VMT)
Materials	4	Allocated based on factors determined in analysis of roadway paving above
All	**100**	**-**

4.2.4.2 Roadside - Roadside activities consisted of mowing, brush and tree cutting, litter pickup, fence and gate repair, etc. These costs were allocated as common costs using VMT.

4.2.4.3 Drainage - This category of activities included cleaning, repairing, and replacing drainage facilities such as culverts and ditches. The costs of these activities were allocated based on VMT.

4.2.4.4 Bridges - Bridge maintenance costs were allocated based on VMT. All major work that significantly impacted the functional capacity of bridges was done as a construction activity.

4.2.4.5 Facilities - Work on rest area and maintenance facilities was included in this activity category. The costs of these activities were allocated based on VMT.

4.2.4.6 Traffic Safety - This category of activity consisted of the repair and replacement of signs, signals, lighting, guardrails, etc. The costs of these activities were allocated based on VMT.

4.2.4.7 Winter Maintenance - Winter maintenance costs included the costs associated with snow removal, sanding, de-icing, etc. These costs were shared between all users based on VMT, with the exception of sanding and deicing costs, which were allocated based on AMT.

4.2.4.8 Equipment/Supervision/Overhead - Costs of equipment maintenance, administration, training, and other miscellaneous activities were included in this activity category. These costs were allocated based on VMT.

4.2.5 Department of Justice (10% of state funds expended)

The State Highway Patrol, under the auspices of the Department of Justice, is funded with highway revenues. Expenditures for the highway patrol were shared between vehicle classes based on VMT.

4.2.6 Bond Interest (3% of state funds expended)

Principal and interest payments were made during each study year on bonds issued prior to the beginning of the study period. These bonds were sold specifically to raise money for highway construction projects; thus some of the indicated construction expenditures were bond funded. From a cost responsibility perspective, expenditure of the bond receipts should only be allocated to the various classes of users once, either as a construction expenditure or as debt retirement (otherwise, more money is being allocated than was actually collected). The decision was made to consider the costs of bond funded construction in the allocation process and omit bond principal repayment as a separate expenditure item. Interest payments on the bond proceeds, however, were allocated to the various vehicle classes using the construction cost allocators, consistent with the manner in which the principal was spent.

<u>4.2.7 Miscellaneous</u> (2% of state funds expended)

Miscellaneous expenditures included such items as nominal payments to the Department of Fish, Wildlife, and Parks for road work. Miscellaneous expenditures were allocated as common costs using VMT.

4. 3 EXPENDITURES OF FEDERAL FUNDS

Personal vehicles, single units, and combination vehicles were found to be responsible for 59, 7, and 34 percent of the federal funds spent on the highway system over the 3 year study period. Federal cost responsibilities by individual vehicle class are reported in Table 4.3-1. By law, federal funds can and were used almost exclusively for highway construction activities (97 percent). On a majority of the construction projects let by MDT, federal funds were used to cover 85 to 90 percent of the costs, with the remainder being paid from state funds. On jointly funded construction projects, the expenditure allocations for state and federal funds were identical, and both were accomplished as outlined above (see Section 4.2.3). The allocations of construction expenditures to specific vehicle classes were accumulated separately, however, for state and federal funds. In this manner, any systematic patterns in the use of state versus federal funds on particular elements of the highway system and for particular types of construction projects were accounted for in the allocation process. The allocation of federal and state construction funds were found to be similar, with 58, 7, and 35 percent of federal expenditures being assigned to personal vehicles, single units, and combination trucks, respectively (the allocation percentages for state construction funds were 56, 10, and 34 percent).

Federal funds used for miscellaneous purposes (3 percent) were allocated as common costs using VMT.

4.4 COMBINED STATE AND FEDERAL EXPENDITURES

Combined state and federal expenditures by vehicle class are presented in Table 4.4-1. These results were simply obtained by adding the cost responsibilities for state and federal expenditures allocated to each vehicle class and dividing by total expenditures. Total expenditures were fairly evenly split between state and federal funds across all vehicle classes. That is, the proportion of funds used from each source typically ranged from 40 to 60 percent of total expenditures. In general, as vehicle size increased, the proportion of federal funds used in

providing that vehicle with highway service nominally increased. This trend in funding source as a function of vehicle size was attributed to the exclusive use of federal funds for construction activities, and the relatively high cost responsibility of heavy vehicles for such activities.

Table 4.3-1 Allocation of Federal Funds Spent on the Highway System

Vehicle Class	Average Annual Expenditures					
	Construction		Other		All	
	Dollars (1000s)	Percent	Dollars (1000s)	Percent	Dollars (1000s)	Percent
Auto	53,954	36.2	2,345	56.1	56,299	36.8
Pickup	32,366	21.7	1,303	31.1	33,668	22.0
Personal Vehicles	**86,320**	**57.9**	**3,647**	**87.2**	**89,967**	**58.7**
SU2	5,951	4.0	100	2.4	6,051	4.0
SU3	2,542	1.7	44	1.0	2,585	1.7
SU4+	516	0.3	5	0.1	521	0.3
BUS	876	0.6	18	0.4	894	0.6
Single Units	**9,885**	**6.6**	**167**	**4.0**	**10,052**	**6.6**
CS3	1,100	0.7	11	0.3	1,111	0.7
CS4	2,086	1.4	20	0.5	2,106	1.4
CS5	31,065	20.9	218	5.2	31,284	20.4
CS6	2,587	1.7	18	0.4	2,604	1.7
CS7+	167	0.1	1	0.0	168	0.1
CT4-	1,687	1.1	24	0.6	1,711	1.1
CT5	3,278	2.2	16	0.4	3,294	2.2
CT6+	1,209	0.8	9	0.2	1,218	0.8
DS5	685	0.5	5	0.1	690	0.5
DS6	741	0.5	5	0.1	746	0.5
DS7	4,243	2.8	21	0.5	4,264	2.8
DS8+	3,908	2.6	21	0.5	3,929	2.6
Comb. Trucks	**52,756**	**35.4**	**369**	**8.8**	**53,125**	**34.7**
All Vehicles	**148,961**	**100.0**	**4,183**	**100.0**	**153,143**	**100.0**

Table 4.4-1 Allocation of Combined State and Federal Expenditures

Vehicle Class	Combined State and Federal Expenditures		Split, State versus Federal Funds	
	Dollars (1000s)	Percent	Percent State	Percent Federal
Auto	125,680	39	55	45
Pickup	76,636	24	56	44
Personal Vehicles	**202,316**	**63**	**56**	**44**
SU2	14,367	4	58	42
SU3	5,593	2	54	46
SU4+	884	0	41	59
BUS	2,050	1	56	44
Single Units	**22,895**	**7**	**56**	**44**
CS3	2,124	1	48	52
CS4	4,089	1	48	52
CS5	53,390	17	41	59
CS6	4,690	1	44	56
CS7+	253	0	34	66
CT4-	3,490	1	51	49
CT5	7,265	2	55	45
CT6+	2,589	1	53	47
DS5	1,063	0	35	65
DS6	1,213	0	39	61
DS7	7,852	2	46	54
DS8+	7,612	2	48	52
Combination Trucks	**95,630**	**30**	**44**	**56**
All Vehicles	**320,841**	**100**	**52**	**48**

4.5 EXPENDITURES PER MILE OF TRAVEL

In addition to calculating the relative cost responsibility for each vehicle configuration for state and federal expenditures on the highway system, the absolute cost attributable to each vehicle configuration was also determined. As previously mentioned in the revenue analysis, this information provided an additional perspective on the equity of user fee payments (beyond that available from relative equity ratios), and it also factored into assessments of the sufficiency of the collected revenue to cover expenditures. State, federal and combined expenditures per unit distance traveled are reported by vehicle class in Table 4.5-1. As would be expected, expenditures steadily increased as vehicle size increased, from a low of 3.19 cents per mile of travel to provide highway service to automobiles, to over 20 cents per mile of travel to provide highway service to the largest vehicle configurations considered in the study (combined expenditure of state and federal funds).

Referring to Table 4.5-1, particularly high expenditures were observed in providing highway service to 5 axle truck, full trailer units (CT5 at 26.63 cents per mile of travel). These vehicles were found to be the only large combination vehicles with a majority of their travel on the secondary system. Thus, this class of vehicles was allocated a significant portion of construction costs from the secondary system. Seven or more axle, tractor, semi-trailers were also observed to have a high cost responsibility (28.18 cents per mile), notably for federal funds spent on the highway system. These vehicles were found to have a relatively high responsibility for bridge expenditures that was deferred across a relatively small amount of travel.

Table 4.5-1 Expenditures per Vehicle Mile of Travel

Vehicle Class	Expenditure, cents/mile		
	State	Federal	Combined
Auto	1.76	1.43	3.19
Pickup	1.96	1.54	3.50
Personal Vehicles	**1.83**	**1.47**	**3.30**
SU2	4.93	3.59	8.52
SU3	4.10	3.52	7.62
SU4+	4.59	6.57	11.16
BUS	3.80	2.94	6.74
Single Units	**4.58**	**3.58**	**8.17**
CS3	5.30	5.81	11.12
CS4	5.91	6.28	12.19
CS5	6.01	8.51	14.53
CS6	7.05	8.80	15.85
CS7+	9.45	18.73	28.18
CT4-	4.33	4.17	8.50
CT5	14.56	12.08	26.63
CT6+	8.82	7.84	16.65
DS5	4.78	8.83	13.60
DS6	6.06	9.67	15.74
DS7	10.23	12.16	22.38
DS8+	10.44	11.13	21.56
Combination Trucks	**6.85**	**8.56**	**15.41**
All Vehicles	**2.38**	**2.18**	**4.56**

5. EQUITY AND SUFFICIENCY

5.1 GENERAL REMARKS

Equity ratios, defined as the proportion of revenue divided by the proportion of expenditures allocated to a class of vehicles, were calculated for all vehicle classes for state funds, federal funds, and their combination. Recall that equity ratios greater than 1.0 indicate that a class of vehicles was over paying its share of highway costs relative to other types of vehicles in the traffic stream. That is, the percent of revenue attributed to that vehicle class exceeded the percent of costs allocated to that vehicle class. Conversely, an equity ratio less than one indicates that a class of vehicles was under paying its share of the costs of providing it with highway service during the study period, relative to other types of vehicles.

Direct comparisons of the sufficiency of the revenue from (or associated with) a specific class of vehicles with the expenditures required to provide them with highway service also offers a useful perspective on highway financing. Notably, equity ratios only provide an indication of relative parity of user revenues from different classes of vehicles; they do not indicate if the revenue collected from a particular group of vehicles is sufficient to cover the actual costs of providing those vehicles with highway service. In evaluating the sufficiency ratios presented in this study, it is important to recognize that they are based on actual expenditures. These ratios, as well as the absolute cost of providing highway service, might change if construction, operation, and maintenance of the system were fully optimized.

5.2 STATE FUNDS

<u>5.2.1 State Equity Ratios</u>

This study found that state expenditures on the highway system were equitably shared across the broad classes of highway users during the study period. Equity ratios of 0.96, 1.17, and 1.04 were calculated for state revenues and expenditures on the system for personal vehicles, single units, and combinations trucks, respectively (see Figure 5.2.1-1). These ratios are all similar in magnitude and range closely around 1.00. In the absence of any studies on the sensitivity of the results of this analysis to variations in inputs, caution should be exercised in attaching too much significance to the nominal differences in these values.

Table 5.2.1-1 Equity and Sufficiency, State Funds

Vehicle Class	Equity			Sufficiency		
	Percent Of Revenue	Percent of Expenditures	Equity Ratio	Revenue, cents/mile	Expenditures, cents/mile	Sufficiency Ratio
Auto	35.5	41.4	0.86	1.62	1.76	0.92
Pickup	29.1	25.6	1.14	2.40	1.96	1.22
Personal Vehicles	**64.6**	**67.0**	**0.96**	**1.90**	**1.83**	**1.04**
SU2	4.9	5.0	0.98	5.22	4.93	1.06
SU3	3.3	1.8	1.85	8.17	4.10	1.99
SU4+	0.5	0.2	2.13	10.52	4.59	2.29
BUS	0.3	0.7	0.42	1.71	3.80	0.45
Single Units	**9.0**	**7.7**	**1.17**	**5.76**	**4.58**	**1.26**
CS3	0.5	0.6	0.89	5.09	5.30	0.96
CS4	1.2	1.2	1.03	6.52	5.91	1.10
CS5	14.2	13.2	1.08	6.97	6.01	1.16
CS6	1.2	1.2	0.97	7.39	7.05	1.05
CS7+	0.1	0.1	1.04	10.61	9.45	1.12
CT4-	2.0	1.1	1.88	8.74	4.33	2.02
CT5	2.0	2.4	0.83	12.97	14.56	0.89
CT6+	1.1	0.8	1.40	13.27	8.82	1.50
DS5	0.3	0.2	1.40	7.21	4.78	1.51
DS6	0.3	0.3	1.18	7.71	6.06	1.27
DS7	1.7	2.1	0.81	8.86	10.23	0.87
DS8+	1.8	2.2	0.81	9.07	10.44	0.87
Combination Trucks	**26.5**	**25.3**	**1.04**	**7.69**	**6.85**	**1.12**
All Vehicles	**100.0**	**100.0**	**1.00**	**2.57**	**2.38**	**1.08**

Greater inequities were observed between the individual vehicle classes than between the broad vehicle categories of personal vehicles, single units, and combination trucks. The equity ratios by individual vehicle class ranged from 0.42 to 1.88, as shown in Table 5.2.1-1. None-the-less, thirteen of the eighteen vehicle classes still had equity ratios in the range between 0.8 and 1.2.

Within the broad category of personal vehicles, the equity ratio for automobiles was 0.86, while it was 1.14 for pickups. While automobiles and pickups were found to have a similar cost responsibility for highway service (as reflected in the expenditure per mile of travel by vehicle type), pickups contributed more revenue for this service than automobiles, notably through increased fuel tax payments.

In the single unit category, 3 and 4+ axle trucks were generally found to be significantly over paying their cost responsibility (equity ratios of around 2). This situation was attributed primarily to the structure of the gross weight fee system. Gross weight fees are assessed as a flat fee, independent of amount of travel. Large single units are used in low mileage applications relative to many other heavy vehicles, and thus the gross weight fees they pay significantly increase their revenue allocation per mile driven. Busses were found to be significantly underpaying their cost responsibility with an equity ratio of only 0.42. This situation was attributed to the fee exemptions granted to busses operated by public agencies and the high proportion of all busses operated by public agencies (in this case, predominantly school busses).

Equity ratios for combination trucks ranged from 0.81 to 1.88, with the heaviest combination trucks, 7 and 8+ axle double trailer units, having the lowest equity ratios.

5.2.2 State Sufficiency Ratios

Revenue and expenditures per vehicle mile of travel are reported in Table 5.2.1-1 for each vehicle class, along with a sufficiency ratio calculated as absolute revenue divided by absolute expenditure per vehicle mile of travel (for each class). A sufficiency ratio greater than one indicates that the revenue from a group of vehicles is more than sufficient to cover the cost of providing them with highway service. Conversely, a sufficiency ratio less than one indicates that the cost of providing that group of vehicles with highway service is higher than the revenue from them. While appearing similar to equity ratios, sufficiency ratios most directly represent the fiscal situation for a single vehicle class, rather than the comparative equity situation between

two or more vehicle classes. Note in reviewing the sufficiency ratios for state funds used on the highway system that, during the three year study period, the total allocated state revenues nominally exceeded total expenditures (ratio of allocated revenues to expenditures of 1.08). Historically, the ratio of state revenues to expenditures fluctuates around 1.0, depending on the level of highway use, specific construction projects under way, level of winter maintenance demands, etc.

Referring to Table 5.2.1-1, sufficiency ratios of 1.04, 1.26, and 1.12, were calculated for personal use vehicles, single units, and combination trucks, respectively. Trends observed in the sufficiency ratios by vehicle class reflected the trends observed in the equity ratios. The highest sufficiency ratios were observed for large single units (SU3+). The lowest sufficiency ratios were calculated for the largest combination vehicles (7 and 8+ axle double trailer units with sufficiency ratios both at 0.87).

5.2.3 Effect of GVW on Equity and Sufficiency

While revenue and expenditures generally are presented in this report by broad vehicle category and specific vehicle class, the basic allocation process can be extended to investigate equity between vehicles in a single class that operate at different gross vehicle weights. Several features of a roadway are influenced by the weight of the vehicles it was designed to serve (e.g., pavement cross-section, bridge strength, etc.), and cost responsibility was observed to vary considerably with operating GVW, notably for the heavier vehicle classes. Estimates of cost responsibility by operating GVW for 5 axle, tractor semi-trailers, for example, are reported in Table 5.2.3-1 (state funds only). The cost responsibility of a 5 axle tractor, semi-trailer operating at a GVW of 70,000 pounds was estimated to be 28 percent lower than that for the same vehicle operating at a GVW of 80,000 pounds, even though the difference in the GVW of the two vehicles was only 13 percent. While cost responsibilities were observed to decrease as vehicle GVW decreased, revenues tended to remain fairly constant. As a result of this situation, equity ratios, calculated as revenues divided by expenditures, were observed to increase with decreasing GVW. The equity ratio for a 5 axle tractor, semi-trailer operating at 70,000 pounds, for example, was estimated to be 1.2. This same vehicle operating at 80,000 pounds had an equity ratio of approximately 0.9.

Table 5.2.3-1 Effect of Operating GVW on Equity within a Vehicle Class, CS5

Operating GVW, pounds	Cost Responsibility, cents/mile	Equity Ratio
50,000	3.70	1.8
60,000	4.08	1.6
70,000	5.27	1.2
80,000	7.30	0.9
90,000[a]	13.39	0.5

[a] weight exceeds legal gross weight limit for this vehicle configuration

The only fee mechanism practically able to adjust to changes in the operating weight of a vehicle on a trip-by-trip basis was the fuel tax (as it reflected changes in the fuel consumption rate of the vehicle operating at different gross weights). Variations in fuel consumption rates with gross weight (and the attendant changes in fuel taxes paid), however, were not large enough to fully reflect changes in highway cost responsibility with gross weight (although such changes were not explicitly modeled in these analyses). While gross weight fees did vary significantly with weight, most vehicles simply registered once annually at the maximum weight they expected to operate at throughout the year. Thus, while their actual operating weight might vary considerably trip-to-trip, their registered (paid) weight was the same.

5.2.4 Comparison with Other Studies

While many states have performed cost allocation studies, it is difficult to definitively compare the results of these studies with those obtained herein, in that every state has a unique highway fee structure, coupled with a unique set of vehicles that have evolved in response to state regulations on vehicle size and weight. None-the-less, the results obtained herein are compared in Table 5.2.4-1 with the results obtained from state cost allocation studies conducted for Idaho (1994), Texas (1993), Delaware (1992), and Oregon (1995). These results indicate the wide range of equity situations that exist in various states between classes of vehicles. The equity situation in Montana is nominally similar to that of Idaho and Oregon, and it is not as extreme as that in Texas (where combination vehicles were found to be significantly underpaying their cost responsibility) or that in Delaware (where combination vehicles were found to be significantly overpaying their cost responsibility).

A second measure used to compare results between these cost allocation studies was the percent of expenditures assigned to the various vehicle classes in each study (see Table 5.2.4-2).

Table 5.2.4-1 Comparisons with the Equity Results of State Cost Allocation Studies from Other States

Vehicle Class	Equity					
	Montana 1999	Montana 1992	Idaho 1994 (Sydec, 1994)	Texas 1993 (Euritt, et al 1993)	Delaware 1992 (Delaware DOT, 1992)	Oregon 1994 (Oregon DOT, 1995)
Auto	0.86	-	0.73	1.25	0.93	-
Pickup	1.14	-	1.03	1.81	1.00	-
Personal Vehicles	**0.96**	**0.96**	**0.86**	**-**	**0.95**	**0.99**
SU2	0.98	-		1.04	1.29	-
SU3	1.85	-	1.27[a]	1.25[d]	0.63[d]	-
SU4+	2.13	-	-	-	-	-
BUS	0.42	-	0.79	0.29	1.33	-
Single Units	**1.17**	**-**	**1.24**	**0.93**	**0.79**	**-**
CS3	0.89	-	-	-	-	-
CS4	1.03	-	-	-	-	-
CS5	1.08	-	-	-	-	-
CS6	0.97	-	-	-	-	-
CS7+	1.04	-	-	-	-	-
CT4-	1.88	-	-	-	-	-
CT5	0.83	-	-	-	-	-
CT6+	1.40	-	-	-	-	-
DS5	1.40	-	-	0.33	-	-
DS6	1.18	-	-	0.13	-	-
DS7	0.81	-	-	-	-	-
DS8+	0.81	-	-	-	-	-
Combination Trucks	**1.04**	**1.07[b]**	**1.41**	**0.39**	**1.59**	**1.03[c]**
All Vehicles	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

[a] - all single unit trucks

[b] - all vehicles 26,000 pounds and heavier

[c] - all vehicles 8,000 pounds and heavier

[d] - SU3+

"-" - value unavailable

Table 5.2.4-2 Comparisons with the Cost Responsibility Results of State Cost Allocation Studies from Other States

Vehicle Class	Cost Responsibility, Percent of State Costs					
	Montana 1999	Montana 1992	Idaho 1994 (Sydec, 1994)	Texas 1993 (Euritt, et al 1993)	Delaware 1992 (Delaware DOT, 1992)	Oregon 1994 (Oregon DOT, 1995)
Auto	41.4	-	45	42	61	-
Pickup	25.6	-	28	14	17	-
Personal Vehicles	**67.0**	**66**	**73**	**56**	**78**	**62**
SU2	5.0	-		5	2	-
SU3	1.8	-	8[a]	2[d]	7[d]	-
SU4+	0.2	-	-	-	-	-
BUS	0.7	-	0	2	1	-
Single Units	**7.7**	**-**	**9**	**10**	**11**	**-**
CS3	0.6	-	-	-	-	-
CS4	1.2	-	-	-	-	-
CS5	13.2	-	-	-	-	-
CS6	1.2	-	-	-	-	-
CS7+	0.1	-	-	-	-	-
CT4-	1.1	-	-	-	-	-
CT5	2.4	-	-	-	-	-
CT6+	0.8	-	-	-	-	-
DS5	0.2	-	-	2	-	-
DS6	0.3	-	-	1	-	-
DS7	2.1	-	-	-	-	-
DS8+	2.2	-	-	-	-	-
Combination Trucks	**25.3**	**25[b]**	**19**	**34**	**11**	**38[c]**
All Vehicles	**100.0**	**100**	**100**	**100**	**1.00**	**1.00**

[a] - all single unit trucks
[b] - all vehicles 26,000 pounds and heavier
[c] - all vehicles 8,000 pounds and heavier
[d] - SU3+
"-" - value unavailable

While revenue structures could differ dramatically between states, highway costs by vehicle type were expected to be somewhat more uniform, notably among western states. In these states, the constitution of the traffic streams and the nature of the highway systems were expected to be similar to those in Montana. Referring to Table 5.2.4-2, the results from the 1999 Montana study are generally similar to those from Idaho, Texas, and Oregon.

The results of the 1992 cost allocation study conducted for Montana are also included in Table 5.2.4-1. The equity situation for personal vehicles remained unchanged between the 1992 and the present study, with a ratio of 0.96 being calculated in both studies for these vehicles. The equity situation for heavy vehicles may have nominally improved between the 1992 and 1999 studies, with the equity ratio for these vehicles shifting from 1.07 to 1.04. Note, however, that these equity ratios were calculated for slightly different vehicles, as the 1.07 value from the 1992 study covered all vehicles weighing more than 26,000 pounds, while the 1.04 value from the 1999 study covered all combination trucks. In any event, the 1992 study found that users were generally sharing the costs of providing them with highway service in an equitable fashion, and this study found that this situation continues to exist, despite significant changes in the tax system since the 1992 study.

5.3 FEDERAL FUNDS

5.3.1 Federal Equity Ratios

Equity ratios of 0.86, 1.46, and 1.17 were calculated for personal use vehicles, single units, and combination trucks, respectively, for federal funds used to finance the state highway system during the study period (see Table 5.3.1-1). Thus, personal use vehicles were found to be relatively underpaying their cost responsibility, while single units and combination trucks were found to be relatively overpaying their cost responsibility. In evaluating these equity ratios, it is important to recall that equity ratios indicate the overpayment or underpayment of a vehicle for its highway service relative to all other vehicle classes. Equity ratios do not indicate if sufficient revenue was collected from any or all vehicles to cover the cost of providing them with highway service. In this case, and as previously mentioned, significantly more federal funds were used on the highway system in Montana than were collected from its users during the study period. Thus, for example, while combination vehicles had an equity ratio greater than 1.0, this result simply means that their relative underpayment for their use of the highway system was not as severe (on a percentage basis) as that for personal use vehicles.

Table 5.3.1-1 Equity and Sufficiency, Federal Funds

Vehicle Class	Equity			Sufficiency			
	Percent Of Revenue	Percent of Expenditures	Equity Ratio	Revenue, cents/mile	Expenditures, cents/mile	Sufficiency Ratio	Revenue minus Expenditures, cents/mile
Auto	28.1	36.8	0.77	0.65	1.43	0.45	-0.78
Pickup	22.7	22.0	1.03	0.94	1.54	0.62	-0.59
Personal Vehicles	**50.9**	**58.7**	**0.87**	**0.75**	**1.47**	**0.51**	**-0.71**
SU2	3.6	4.0	0.91	1.94	3.59	0.54	-1.66
SU3	4.9	1.7	2.90	6.06	3.52	1.72	2.53
SU4+	0.7	0.3	2.06	8.05	6.57	1.22	1.48
BUS	0.3	0.6	0.46	0.81	2.94	0.27	-2.14
Single Units	**9.5**	**6.6**	**1.44**	**3.07**	**3.58**	**0.85**	**-0.53**
CS3	0.9	0.7	1.23	4.24	5.81	0.73	-1.59
CS4	1.4	1.4	1.00	3.72	6.28	0.59	-2.57
CS5	23.2	20.4	1.14	5.74	8.51	0.67	-2.79
CS6	2.0	1.7	1.18	6.18	8.80	0.70	-2.64
CS7+	0.1	0.1	0.90	9.99	18.73	0.53	-8.75
CT4-	1.7	1.1	1.49	3.69	4.17	0.88	-0.48
CT5	2.4	2.2	1.10	7.90	12.08	0.65	-4.22
CT6+	1.4	0.8	1.73	8.07	7.84	1.03	0.21
DS5	0.5	0.5	1.11	5.80	8.83	0.66	-3.04
DS6	0.5	0.5	1.04	5.95	9.67	0.61	-3.74
DS7	2.7	2.8	0.98	7.05	12.16	0.58	-5.13
DS8+	2.9	2.6	1.13	7.49	11.13	0.67	-3.67
Combination Trucks	**39.7**	**34.7**	**1.14**	**5.81**	**8.56**	**0.68**	**-2.77**
All Vehicles	**100.0**	**100.0**	**1.00**	**1.29**	**2.18**	**0.59**	**-0.89**

Equity ratios for federal funds are reported by individual vehicle class in Table 5.3.1-1. These ratios were not as closely clustered around unity as they were for state funds. Equity ratios for 8 out of the 18 vehicle classes considered in this study fell outside of the range of 0.8 to 1.2 (see Table 5.3.1-1). None-the-less, many of the various observations on equity ratios by individual vehicle class previously made for state funding of the highway system were also valid for federal funds used for the highway system. Notably, a) automobiles were found to be underpaying their cost responsibility relative to pickup trucks (equity ratios of 0.77 and 1.03, respectively), b) large single units (SU3+) were found to be significantly overpaying their cost responsibilities (equity ratios in excess of 2), and c) busses were significantly underpaying their cost responsibility (equity ratio of 0.46).

5.3.2 Federal Sufficiency Ratios

Sufficiency ratios for federal revenues and expenditures are reported in Table 5.3.1-1. Sufficiency ratios of 0.51, 0.86, and 0.68 were calculated for personal vehicles, single units, and combination trucks, respectively. These sufficiency ratios are consistently less than 1.0, indicating that each category of vehicle is underpaying their cost responsibility for federal expenditures on the Montana highway system. With respect to the sufficiency of revenues to cover costs for individual vehicle classes, only 3 out of 18 vehicle classes were found to have sufficiency ratios greater than unity, namely, large single units (3SU, 4SU) and large straight trucks pulling full trailers (CT6+). The simple difference between revenue and expenditure per mile of travel is also reported in Table 5.3.1-1. Personal vehicles, single units, and combination trucks were found to underpay their federal cost responsibility by 0.72, 0.51, and 2.75 cents per mile, respectively.

5.3.3 Comparison with Results from the Federal Cost Allocation Study

The equity ratios calculated in this study for federal revenues and expenditures in Montana are compared with the equity ratios calculated by FHWA for federal funds used nationally on the federal-aid highway system in Table 5.3.3-1. The equity ratios calculated in this study were generally lower for personal use vehicles and higher for single units and combination trucks than were found in FHWA's national study. Equity ratios of 0.86 and 1.05 were found for personal vehicles in the Montana study and in and FHWA's national study,

Table 5.3.3-1 Federal Equity Ratios as Calculated in the MSU Analysis and in the Federal Cost Allocation Study (FHWA, 1997)

Vehicle Class	Equity Ratio	
	MSU Analysis	Federal Analysis, 1993-1995
Auto	0.77	0.93
Pickup	1.03	1.38
Personal Vehicles	**0.87**	**1.05**
SU2	0.91	-
SU3	2.90	-
SU4+	2.06	-
BUS	0.46	0.14
Single Units	**1.44**	**0.86**
CS3	1.23	-
CS4	1.00	-
CS5	1.14	-
CS6	1.18	-
CS7+	0.90	-
CT4-	1.49	-
CT5	1.10	-
CT6+	1.73	-
DS5	1.11	-
DS6	1.04	-
DS7	0.98	-
DS8+	1.13	-
Combination Trucks	**1.14**	**0.95**
All Vehicles	**1.00**	**1.00**

respectively. At the other end of the spectrum, equity ratios of 1.14 and 0.95 were calculated, respectively, for combination trucks in this study and in the federal study.

These apparently disparate results could both be correct, in that the results of the federal study represent the average situation across the United States, while the results from this study are specific to conditions in Montana. In an effort to better understand these equity results, the underlying revenues and expenditures allocated per mile of travel in the two studies were compared. This comparison is presented in Table 5.3.3-2. Referring to this table, the revenue allocated to each class of vehicles (per mile of travel) was similar in both studies, although the revenue allocated in this study was systematically larger in magnitude than the revenue allocated

Table 5.3.3-2 Federal Revenue and Expenditure Allocations as Calculated in the MSU Analysis and in the Federal Cost Allocation Study (FHWA, 1997)

Vehicle Class	Federal Revenue Allocation, cents per mile		Federal Expenditure Allocation, cents per mile	
	MSU Analysis	Federal Study, 1994	MSU Analysis	Federal Study, 1993-1995[a]
Auto	0.65	0.55	1.43	0.61
Pickup	0.94	0.79	1.54	0.60
Personal Vehicles	**0.75**	**0.61**	**1.47**	**0.61**
SU2	1.94	2.49	3.59	-
SU3	6.06	4.34	3.52	-
SU4+	8.05	8.19	6.57	-
BUS	0.81	0.30	2.94	2.43
Single Units	**3.07**	**2.69**	**3.58**	**3.38**
CS3	4.24	2.60	5.81	-
CS4	3.72	3.17	6.28	-
CS5	5.74	5.53	8.51	-
CS6	6.18	6.29	8.80	-
CS7+	9.99	7.26	18.73	-
CT4-	3.69	9.47	4.17	-
CT5	7.90	7.42	12.08	-
CT6+	8.07	7.18	7.84	-
DS5	5.80	5.25	8.83	-
DS6	5.95	5.74	9.67	-
DS7	7.05	7.20	12.16	-
DS8+	7.49	7.52	11.13	-
Combination Trucks	**5.81**	**5.37**	**8.56**	**6.38**
All Vehicles	**1.29**	**0.88**	**2.18**	**0.94**

a - Values calculated from information presented in the 1997 Federal Cost Allocation Study (FHWA, 1997) as expenditures during the base period 1993 to 1995 divided by VMT for 1994

"-" insufficient information available to calculate value

in the federal study. (Federal revenue per vehicle mile of travel was expected to be generally independent of the geographic area from which it was collected, and thus this difference in revenue allocation between this study and the federal study is still under investigation.) The costs to the federal government of providing each class of vehicles with highway service were generally found to be significantly higher in this study relative to the costs allocated in the federal study. The cost of providing highway service averaged across all vehicles in the traffic

stream, for example, was found to be 2.18 cents per mile in this study, compared to 0.94 cents per mile in the federal study. The implication of this result is that highway costs per unit of travel are higher in Montana than the national average. This outcome is not surprising, in that the low volume of traffic on Montana's highways results in the fixed costs of providing highway service being shared across fewer users compared to the situation in the rest of the country.

5.4 COMBINED STATE AND FEDERAL FUNDS

5.4.1 Combined Equity Ratios

Equity ratios of 0.95, 1.25, and 1.05 were calculated for personal vehicles, single units, and combination trucks for combined state and federal funds used on the highway system during the study period. These values, closely paralleling the values calculated for the state funds used on the highway system, generally indicate that personal vehicles and combination trucks were nominally paying their relative share of highway costs, while single units are over paying their relative share of highway costs. Equity ratios for individual vehicle classes are reported in Table 5.4.1-1. Trends observed in these ratios closely follow the observed in the equity ratios calculated independently for state and federal funds.

5.4.2 Combined Sufficiency Ratios

Sufficiency ratios are presented by vehicle class for combined state and federal funds used on the highway system in Table 5.4.1-1. The sufficiency ratios for all vehicle classes were less than 1.0, indicating that the revenue from every class of vehicles was inadequate to cover the costs associated with providing them with highway service. Sufficiency ratios of 0.74, 0.87, and 0.93 were calculated for personal vehicles, single units, and combination trucks, respectively. The sufficiency ratios generally increased with vehicle size, from a value of 0.73 for automobiles, to a value of 0.95 for 8+ axle double trailer units. The absolute difference between revenue and expenditures by vehicle type (rather than the ratio of revenues to expenditures) ranged closely around 1 cent per mile of travel for all vehicle classes.

Table 5.4.1-1 Equity and Sufficiency, Combined State and Federal Funds

Vehicle Class	Equity			Sufficiency		
	Percent Of Revenue	Percent of Expenditures	Equity Ratio	Revenue, cents/mile	Expenditures, cents/mile	Sufficiency Ratio
Auto	33.0	39.2	0.84	2.27	3.12	0.73
Pickup	27.0	23.9	1.13	3.34	4.47	0.75
Personal Vehicles	**60.0**	**63.1**	**0.95**	**2.65**	**3.61**	**0.74**
SU2	4.5	4.5	0.99	7.16	8.15	0.88
SU3	3.8	1.7	2.21	14.23	16.44	0.87
SU4+	0.5	0.3	1.97	18.57	20.54	0.90
BUS	0.3	0.6	0.44	2.51	2.95	0.85
Single Units	**9.1**	**7.1**	**1.28**	**8.83**	**10.11**	**0.87**
CS3	0.7	0.7	0.99	9.34	10.33	0.90
CS4	1.3	1.3	0.99	10.24	11.24	0.91
CS5	17.2	16.6	1.04	12.71	13.75	0.92
CS6	1.5	1.5	1.01	13.57	14.59	0.93
CS7+	0.1	0.1	0.86	20.60	21.47	0.96
CT4-	1.9	1.1	1.73	12.43	14.16	0.88
CT5	2.1	2.3	0.93	20.87	21.79	0.96
CT6+	1.2	0.8	1.52	21.34	22.85	0.93
DS5	0.4	0.3	1.13	13.01	14.14	0.92
DS6	0.4	0.4	1.03	13.66	14.68	0.93
DS7	2.1	2.4	0.84	15.91	16.75	0.95
DS8+	2.2	2.4	0.91	16.56	17.47	0.95
Combination Trucks	**30.9**	**29.8**	**1.04**	**13.50**	**14.53**	**0.93**
All Vehicles	**100.0**	**100.0**	**1.00**	**3.86**	**4.86**	**0.79**

6. FHWA SPREADSHEET ANALYSIS

6.1 GENERAL REMARKS

Equity and sufficiency analyses of state revenues and expenditures on the highway system were also done using software being developed by FHWA specifically to support state cost allocation studies (FHWA, 1999). This software consists of a series of spreadsheets that primarily serve as an input/output mechanism for allocation algorithms programmed in Visual Basic. The user provides extensive data to the program regarding a) the elements of the highway system, b) highway usage by vehicle configuration, c) revenue by amount and source, d) expenditure by type of activity, and e) allocation philosophy to be followed. The program generates revenue and costs per vehicle mile of travel and attendant equity ratios by vehicle class for 21 different vehicle classes.

At the time of this study, the FHWA software was in the final phases of its development. Only limited documentation was available to support its use, and the performance had not been fully validated. None-the-less, this software offered an opportunity to perform an "independent" calculation using the same input data as in the analysis presented above. Note that the term independent refers primarily to the calculational part of the cost allocation process (as opposed to the conceptual part), as the federal software to a large extent gives the user the flexibility to implement their own allocation strategies. The intent in this application was to implement the FHWA software according to the allocation strategies used in the in-house analysis performed above.

The federal software implements the basic cost occasioned approach to highway cost allocation. On the revenue side, the program closely follows most of the procedures described above to take net revenue and assign it back to the vehicles from which it was collected. For fuel tax revenue, for example, the FHWA program acts on user inputs of 1) split by fuel type, 2) fuel consumption rate, and 3) total miles traveled by vehicle class to apportion this revenue back to vehicles from which it was collected.

On the expenditure side, the federal software was sufficiently flexible that the same general cost allocation strategies discussed above for various types of expenditures could be used in the federal program. While the strategies were kept constant, one significant difference did exist in their implementation between the two models. The federal software allocated costs of pavement preservation activities using NAPCOM, which was developed for the federal cost allocation study; MSU used a basic facility approach, coupled with an AASHTO ESAL based model (with some customization to conditions in Montana) for this purpose. The intention of both approaches is identical; that is, to use engineering procedures coupled with cost information to reasonably assign the cost of roadway preservation to the various vehicles that degrade it. The NAPCOM model uses a mechanistic approach to relate vehicle loads to the engineering response of the pavement, which in turn is related to its deterioration. The model accounts for and reports the load versus non-load related portion of these costs. The AASHTO ESAL model used in the MSU based analysis employs an empirically derived relationship between vehicle loads and pavement deterioration. The NAPCOM model reportedly represents the state-of-the-art in predicting pavement response (FHWA, 1999). While the NAPCOM model might be expected to yield better results than the AASHTO ESAL approach, the AASHTO ESAL approach used herein was customized to conditions in Montana using data on historical pavement performance (Stephens, et al, 1996).

While the federal software is a powerful cost allocation analysis tool, it is by design a tool developed to support a variety of users. In some instances it was difficult to customize the model to conditions in Montana. These difficulties generally involved the inability of the software to conceptually model a known allocation phenomena, or the inability of the software to take advantage of detailed information that might be available from an unexpected source on how some or all of an item should be allocated. The MSU analysis, developed solely for Montana, was better able to handle these situations. Note that future versions of the federal software are also expected to allow more opportunity for customization to state specific situations.

6.2 BASIC IMPLEMENTATION

The basic revenue and expenditure information input into the federal spreadsheets is presented in Tables 6.2-1 and 6.2-2, respectively. The revenue and expenditure categories used

in the federal software were not identical to those used in the MSU spreadsheets, so some manipulation of the information from Sections 3 and 4 above was necessary. The program also required information on the characteristics of the system and the users, which was drawn from the material presented in Section 2.

Table 6.2-1 Revenue Inputs, FHWA Cost Allocation Software

Source of Revenue	Amount ($1000s)
Gasoline Tax	107,577
Diesel and Other Fuel Tax	38,689
Weight Fees	18,519
New Vehicle Sales Tax	8,866
Miscellaneous Fees Paid to Motor Carrier Services	2,680
Miscellaneous Revenue	4,047
Total	**180,377**

Table 6.2-2 Expenditure Inputs, FHWA Cost Allocation Software

Type of Expenditure	Amount ($1000s)
Construction	72,229
Maintenance	62,098
General Operations and Highway Patrol	20,173
Motor Carrier Services Operations	4,197
Total	**167,697**

6.3 RESULTS

Equity ratios determined using the FHWA software are presented by vehicle type in Table 6.3-1. The equity ratios for personal vehicles, single units, and combination trucks ranged closely around one, with specific values by vehicle category of 1.12, 1.00, and 0.91, respectively. Thus, personal vehicles were calculated to be nominally overpaying their share of highway costs, single units were found to be exactly paying their relative share of highway costs, and combination trucks were found to be nominally underpaying their share of highway costs. Within the passenger vehicle category, automobiles were found to be nominally underpaying their relative share of highway costs, with an equity ratio of 0.97, while pickups were overpaying their relative cost responsibility with an equity ratio of 1.16. Three and 4+ axle single units trucks were found to be overpaying their cost responsibility with equity ratios of 1.19 and 1.48. In the category of combination vehicles, equity ratios generally decreased as vehicle size increased within each vehicle type (i.e., tractor, semi-trailer; truck, full trailer; double trailer). Within combination vehicles, the lowest equity ratios were calculated for 7 and 8+ axle double trailers (equity ratios of 0.64 and 0.58, respectively).

Sufficiency ratios calculated for each type of vehicle using information from the FHWA spreadsheet analysis are presented in Table 6.3-1. These ratios ranged from a low value of 0.38 for busses, to a high value of 2.65 for 4 axle truck/trailer units. Revenues and expenditures per vehicle mile of travel, also reported in Table 6.3.1, generally increased as vehicle size increased within each type of configuration.

6.4 COMPARISON WITH MSU ANALYSIS

The equity ratios from the MSU and FHWA analyses of state funding of the highway system are shown by vehicle class in Table 6.4-1. The results from the two analyses are similar in general magnitude, and many of the trends within the broad vehicle categories with respect to equity for individual classes of vehicles are observed in both sets of results. The primary difference in the results of the two calculations consisted of a shift in responsibility for system expenditures from light to heavier vehicles in the FHWA analysis relative to the MSU analysis. This shift in expenditure allocations resulted in an attendant shift in equity ratios. The equity ratios for personal vehicles calculated to be nominally less than one in the MSU analysis were calculated to be nominally greater than one in the FHWA analysis. Correspondingly, the equity

Table 6.3-1 Equity and Sufficiency Ratios, State Funds, FHWA Cost Allocation Software

Vehicle Class	Equity			Sufficiency		
	Percent Of Revenue	Percent of Expenditures	Equity Ratio	Revenue, cents/mile	Expenditures, cents/mile	Sufficiency Ratio
Auto	36.8	37.9	0.97	1.69	1.61	1.05
Pickup	27.7	23.9	1.16	2.28	1.83	1.25
Personal Vehicles	**64.5**	**61.8**	**1.04**	**1.90**	**1.69**	**1.12**
SU2	4.4	4.7	0.94	4.73	4.68	1.01
SU3	4.1	3.4	1.19	9.97	7.78	1.28
SU4+	0.4	0.3	1.48	10.01	6.27	1.60
BUS	0.3	0.8	0.34	1.58	4.37	0.36
Single Units	**9.2**	**9.2**	**1.00**	**5.63**	**5.32**	**1.06**
CS3	0.5	0.5	1.01	5.06	4.67	1.08
CS4	1.3	1.0	1.30	6.74	4.83	1.40
CS5	14.6	16.1	0.91	7.15	7.33	0.98
CS6	1.2	1.6	0.77	7.32	8.82	0.83
CS7+	0.0	0.1	0.64	7.65	11.04	0.69
CT4-	2.0	0.8	2.47	8.90	3.36	2.65
CT5	1.9	2.7	0.74	12.88	16.29	0.79
CT6+	0.9	0.8	1.11	10.05	8.41	1.20
DS5	0.3	0.2	1.46	7.73	4.93	1.57
DS6	0.4	0.2	1.91	8.29	4.04	2.05
DS7	1.6	2.4	0.64	8.00	11.64	0.69
DS8+	1.6	2.8	0.58	9.44	15.16	0.62
Combination Trucks	**26.3**	**29.0**	**0.91**	**7.64**	**7.85**	**0.97**
All Vehicles	**100.0**	**100.0**	**1.00**	**2.57**	**2.33**	**1.10**

Table 6.4-1 Equity Ratios, MSU and FHWA Analyses of State Funds

Vehicle Class	Equity Ratios, State Funds	
	MSU Spreadsheets	FHWA Spreadsheets
Auto	0.86	0.97
Pickup	1.14	1.16
Personal	**0.96**	**1.04**
SU2	0.98	0.94
SU3	1.85	1.19
SU4+	2.13	1.48
BUS	0.42	0.34
Single Units	**1.17**	**1.00**
CS3	0.89	1.01
CS4	1.03	1.30
CS5	1.08	0.91
CS6	0.97	0.77
CS7+	1.04	0.64
CT4-	1.88	2.47
CT5	0.83	0.74
CT6+	1.40	1.11
DS5	1.40	1.46
DS6	1.18	1.91
DS7	0.81	0.64
DS8+	0.81	0.58
Combination Trucks	**1.04**	**0.91**
All Vehicles	**1.00**	**1.00**

ratios calculated to be nominally greater than one for combination trucks in the MSU analysis were found to be nominally less than one in the FHWA analysis.

The shift in expenditures from light to heavy vehicles observed in the FHWA analysis resulted primarily from a shift in the allocation of roadway construction costs on the non-interstate NHS and secondary systems from light to heavy vehicles. Using the NAPCOM model, the FHWA program assigned 84 and 73 percent of roadway construction costs on the non-interstate NHS and secondary systems, respectively, as load related.   Only 71 and 52 percent of roadway construction costs on the non-interstate NHS and secondary systems, respectively, were found to be load related in the MSU analysis.   Since responsibility for load related costs fall

primarily on heavier versus lighter vehicles, a smaller portion of roadway construction costs were allocated to heavy vehicles in the MSU analysis relative to the FHWA analysis.

A summary of the fraction of roadway construction costs assigned in the MSU and FHWA analyses as load related for each element of the highway system is presented in Table 6.4-2. The FHWA and the MSU analyses assigned similar proportions of roadway construction costs as load versus non-load related on the interstate, primary, and urban systems. In response to the dramatic reduction in traffic on the secondary system, however, the MSU analysis predicted a substantial decrease in the load related fraction of roadway construction costs on this system. The FHWA analysis used almost the same load versus non-load related cost split for the primary and secondary systems, even though the average volume of traffic on the two systems differed by almost a factor of 3. The FHWA analysis appeared to reasonably assess the load related fraction of construction costs on the non-interstate NHS system, while the MSU analysis treated this system similar to the state primary system. In light of this situation, further analyses need to be done with the FHWA spreadsheets to verify that the pavement deterioration model is being correctly applied and that it accurately represents pavement performance in Montana.

Table 6.4-2 Proportion of Overlay Costs Allocated as Load Related, MSU and FHWA Cost Allocation Algorithms

System	Average Daily Traffic	Percent of Overlay Costs Allocated as Load Related	
		MSU Analysis	FHWA Analysis
Interstate	5179	90	92
NHS	2261	71	84
Primary	1067	72	75
Secondary	375	52	73
Urban	5982	90	90

7. ALTERNATE FISCAL SCENARIOS

7.1 GENERAL REMARKS

The cost allocation analysis completed above provided a model of the financial side of the highway system that could be used to investigate effects of changes in the revenue or expenditure streams on the equity of user fee payments. If major inequities in fee payments had been discovered across various classes of users, this model could have been used to identify possible changes in the tax structure that would improve equity while maintaining the basic sufficiency of highway revenues to cover expenditures. The results of his study, indicated that at the state level, however, highway users already were generally paying their share of highway costs. While inequities between vehicle classes were more evident at the federal level relative to the state level, consideration of changes in the federal funding structure were judged to be beyond the scope of this study.

The one fiscal change that was investigated in this study consisted of assessing the impact on user equity of eliminating the state's new vehicle sales tax and implementing a single fee on light vehicles that would replace both this tax and light vehicle property taxes. Such legislation was put forth by the 1999 Montana legislature (1999b), and it will be voted on by the citizens of Montana in a referendum scheduled in November, 2000.

7.2 NEW LIGHT VEHICLE FEE

The new light vehicle fee is based simply on a vehicle's age, with the fees assessed according to the schedule in Table 7.2-1. Note that local government can augment this fee with a local option tax of up to 0.5 percent of the taxable value of the vehicle (with voter approval).

Table 7.2-1 New Light Vehicle Fee Schedule

Vehicle Age, years	Annual Light Vehicle Fee, $
4 or less	195
5 to 10	65
11 or more	6

To replace the highway revenue that was generated by the new vehicle sales tax, light vehicle fees collected under this statute from vehicles being registered for the first time in Montana (including both new vehicles and transfer registrations from out-of-state) are to be deposited to the highway account. If this tax had been in place during the study period, an estimated $7,598,000 would have been deposited annually to the highway account in lieu of the $8,860,000 generated annually by the new vehicle sales tax. This estimate is based on data from a) the Motor Vehicle Division of the Justice Department (1999a) regarding current light vehicle registrations, b) the National Automobile Dealers Association (1999) regarding new vehicle registrations, and c) the Bureau of the Census (1999) regarding immigration trends into Montana (from which the attendant number of out-of-state vehicles annually expected to transfer their registrations to Montana was calculated). Forty thousand new vehicles were estimated to be registered in Montana annually during the study period, coupled with approximately 5,000 registrations transferred annually from other states. The expected revenue for these vehicles was calculated from the light vehicle fee schedule assuming no local option tax was levied, and with due consideration of the 10 percent county court distribution of the collected fees.

7.3 EFFECT OF NEW LIGHT VEHICLE FEE ON HIGHWAY FINANCING

The highway finance situation would have been only nominally affected during the study period if the new vehicle sales tax had been eliminated and the new light vehicle fee system had been instituted. From an equity perspective, the majority of the reported revenue from the new vehicle sales tax came from light vehicles, which is the same group of vehicles taxed under the new light vehicle fee system. Equity ratios for this case are presented in Table 7.3-1, and are almost identical to those for the actual tax structure in place during the study period. From a sufficiency perspective, the change in total revenues under the new system amounted to less than 1 percent.

Table 7.3-1 Equity of State Highway Funds under the New Light Vehicle Fee

Vehicle Class	Revenue Allocation, Percent	Expenditure Allocation, Percent	Equity Ratio
Auto	35.4	41.4	0.86
Pickup	29.1	25.6	1.13
Personal Vehicles	**64.5**	**67.0**	**0.96**
SU2	4.9	5.0	0.99
SU3	3.3	1.8	1.85
SU4+	0.5	0.2	2.10
BUS	0.3	0.7	0.42
Single Units	**9.0**	**7.7**	**1.17**
CS3	0.5	0.6	0.90
CS4	1.2	1.2	1.03
CS5	14.2	13.2	1.08
CS6	1.2	1.2	0.98
CS7+	0.1	0.1	1.03
CT4-	2.0	1.1	1.89
CT5	2.0	2.4	0.83
CT6+	1.2	0.8	1.41
DS5	0.3	0.2	1.41
DS6	0.3	0.3	1.19
DS7	1.7	2.1	0.81
DS8+	1.8	2.2	0.81
Combination Trucks	**26.5**	**25.3**	**1.05**
All Vehicles	**100.0**	**100.0**	**1.00**

8. SUMMARY AND CONCLUSIONS

8.1 SUMMARY AND CONCLUSIONS

This cost allocation study found that the broad vehicle classes of personal vehicles, single units, and combination trucks were generally paying their share of the cost of the Montana state highway system during the study period 1994 to 1996. Equity ratios calculated for state funds used on the system were 0.96, 1.17, and 1.04 for personal vehicles, single units, and combination trucks, respectively. Equity results for individual vehicle classes within the broad vehicle categories referred to above were more disparate, although the equity ratios for 13 of the 18 vehicle classes considered fell in the range from 0.8 to 1.2. Within the personal vehicle class, automobiles were found to be nominally underpaying their relative cost responsibility (equity ratio of 0.86), while pickups were nominally overpaying their cost responsibility (equity ratio of 1.14). Within the category of single units, 3 and 4+ axle trucks were found to have equities ratios significantly greater than 1.0 (1.85 and 2.13, respectively), while busses were significantly under paying their relative cost responsibility (equity ratio of 0.42). Equity ratios for various types of combination trucks ranged from 0.81 to 1.88, with the lowest equity ratios being calculated for the largest double trailer configurations (equity ratio of 0.81). Finally, equity ratios for particular vehicle configurations varied significantly with specific operating weight. Five axle tractor, semi-trailers operating at 70,000 and 80,000 pounds, for example, had estimated equity ratios of 1.2 and 0.9, respectively.

Equity ratios for federal funds used on the highway system were more dispersed about 1.0 relative to the equity ratios calculated for state funds. Equity ratios of 0.87, 1.44, and 1.14 were calculated for federal funds for personal vehicles, single units, and combination trucks, respectively. Similar to the state results, a) automobiles were found to be under paying their cost responsibility while pickups were nominally over paying their cost responsibility, b) large single units (3 and 4+ axle trucks) were found to be significantly overpaying their cost responsibility, and c) busses were found to be substantially under paying their cost responsibility.

Equity ratios for combined state and federal funds used on the highway system ranged closely around 1.0. Equity ratios of 0.95, 1.28, and 1.04 were calculated for personal vehicles, single units, and combination vehicles, respectively.

While state revenues and expenditures on the highway system generally balanced, federal expenditures on the system significantly exceeded federal revenues attributable to Montana sources, and all vehicles were found to be underpaying their federal cost responsibility from a sufficiency perspective. While combination trucks, for example, had an equity ratio greater than 1, this ratio indicated that they were underpaying their cost responsibility proportionally less than the other vehicles in the traffic stream. In absolute magnitude, under payment for federal expenditures on the highway system were found to be 0.71, 0.55, and 2.77 cents per mile of travel for personal vehicles, single units, and combination trucks, respectively. This general under payment of cost responsibility resulted in the federal equity ratios calculated for Montana being different from those calculated in the federal cost allocation study for average conditions across the country. The federal study found equity ratios of 1.05, 0.86, and 0.95 for personal vehicles, single units, and combination trucks, respectively

The equity situation for state funds used on the highway system was also investigated using highway cost allocation software being developed by FHWA. The results of this second analysis also indicated that highway users in Montana are generally equitably sharing the costs of providing them with highway service. The FHWA software generated equity ratios of 1.04, 1.00, and 0.91 for personal vehicles, single units, and combination trucks, respectively. These results are based on the same data and allocation strategies that were used in the cost allocation algorithms specifically developed at MSU for this study. These results are similar in magnitude, but shifted by vehicle class, relative to the MSU results. Equity ratios of 0.96 and 1.04 were generated for personal vehicles, while ratios of 1.04 and 0.95 were generated for combination trucks, using the MSU and FHWA algorithms, respectively. This difference in equity ratios was traced to the manner in which pavement overlay costs were allocated in the two analyses. The two analyses treated the interstate, primary, and urban systems in a similar fashion for pavement overlay costs. The FHWA analysis, however, assigned more of the costs on the non-interstate NHS and secondary systems as load related vs. non-load related compared to the MSU analysis. While the FHWA analysis used a more contemporary pavement deterioration model for this allocation than was used in the MSU algorithms, the MSU pavement deterioration model had previously been calibrated to conditions in Montana. The result of this difference in pavement cost allocation was a shift in the allocation of cost responsibility in the FHWA analysis from light to heavier vehicles, relative to the MSU analysis, and an attendant shift in equity ratios.

Possible changes in user equity at the state level due to changes in highway revenues proposed by the 1999 state legislature were also investigated in this study. The tax changes consisted of the elimination of the new vehicle sales tax and the imposition of a new light vehicle fee (this initiative will be put before the voters in November, 2000). An analysis of the attendant changes in the highway revenue stream found that equity and sufficiency would be minimally effected by these changes

8.2 RECOMMENDED FUTURE WORK

The cost allocation model developed for the Montana highway system as part of this project should be used a) to investigate the effect on user equity of changes in the administration of the system that have occurred since the inception of the study, and b) to explore the sensitivity of the equity results to the inputs in the model. As previously mentioned, two major changes in system administration have occurred since the inception of this study that could have a significant effect on the equity of highway user payments:

1) Federal funds available for construction activities on the state's highways were increased by approximately 60 percent in the bill re-authorizing the federal highway program (TEA-21). This influx of funds is significant in magnitude and is in one particular area of highway activity (rather than being spread across all activities); therefore, it could have an effect on relative user equity.
2) The state is assuming responsibility for maintenance of the secondary highway system. Historically, the state funded capital investment projects on the secondary system, while local government agencies were responsible for its maintenance. Once again, as this change affects a single highway activity, it could therefore influence relative user equity.

Expected changes in expenditure patterns associated with these two events could be factored into the cost allocation analyses and a prediction made of any expected changes in equity.

The significance of changes in equity and in any differences in equity between user groups that is identified in these analyses is somewhat uncertain, as the sensitivity of the analysis to variations in the input data is uncertain. Sensitivity studies should be done in which various inputs to the analysis are varied over a finite range of realizations while the attendant equity results are reviewed.

9. REFERENCES

Ala, M. (1998), personal communication regarding revenue collected by the Motor Carrier Services Division of MDT, Helena, Montana.

Bureau of the Census (1998), “State Population Estimates and Demographic Components of Population Change: April 1, 1990 to July 1, 1998”, (ST-98-2), Washington, D.C.

Battelle Highway Cost Allocation Team (1995), "Consideration of Externalities in Highway Cost Allocation", Highway Cost Allocation White Paper, Preliminary Draft.

Clark, D. (1999), personal communication, Engineering Division, Montana Department of Transportation, Helena, Montana.

American Association of State Highway and Transportation Officials (1993), “AASHTO Guide for Design of Pavement Structures”, AASHTO, Washington, D.C.

Delaware Department of Transportation (1992), “Delaware Highway Cost Allocation Study”, prepared by the Division of Planning, Delaware Department of Transportation and the Bureau of Economic Research at the University of Delaware.

Environmental Protection Agency (1997), “Annual Emissions and Fuel Consumption for an “Average” Passenger Car and Light Truck”, EPA 420-F-97-037, U.S. Environmental Protection Agency, Washington, D.C.

Euritt, M.A, et al (1993), “Texas Highway Cost Allocation Analysis and Estimates, 1992-1994”, Center for Transportation Research, Bureau of Engineering Research, University of Texas at Austin.

Federal Highway Administration (1995), “1994 Highway Statistics”, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration (1996), “1995 Highway Statistics”, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration (1997a), “1996 Highway Statistics”, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration (1997), “1997 Federal Highway Cost Allocation Study”, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration (1999), “State Highway Cost Allocation Spreadsheets, First Full Working Version for Production Use by the States”, Federal Highway Administration, Washington, D.C., June 15, 1999.

Gilmore, G. (1999), personal communication, Highways and Engineering Division, Montana Department of Transportation, Helena, Montana.

Highway Research Board (1962), "The AASHO Road Test, Report 5, Pavement Research", SR 61E, Highway Research Board, National Research Council, Washington, D.C.

Kirby, Jeff (1998), personal communication, Administration Division, Montana Department of Transportation, Helena, Montana.

Montana Code Annotated (1997), Montana Legislative Council, State of Montana, Helena, Montana.

Montana Department of Transportation (1994), "Montana Bridges 1994", Bridge Bureau and Transportation Planning Division of the Montana Department of Transportation, Helena, Montana.

Montana Department of Transportation (1997a), "1997 Montana Road Log", Data and Statistics Bureau, Montana Department of Transportation, Helena, Montana.

Montana Department of Transportation (1997b), Traffic Data Files provided by the Data and Statistics Bureau, Montana Department of Transportation, Helena, Montana.

Montana Department of Transportation (1997c), "Combined Long Range Planning Document – Hwy Special Revenue Funds", Montana Department of Transportation, Helena, Montana, Sept. 1997.

Montana Department of Transportation (1998), Maintenance Expenditure by Activity, Maintenance and Equipment Bureau, Montana Department of Transportation, Helena, Montana.

Montana State Legislature (1999a), Senate Bill 333, Montana State Legislature, Helena, Montana.

Montana State Legislature (1999b), House Bill 540, Montana State Legislature, Helena, Montana.

Motor Vehicle Division, Department of Justice (1999a), personal communication on vehicle registration data, Motor Vehicle Division, Department of Justice, Deer Lodge, Montana.

Motor Vehicle Division, Department of Justice (1999b), personal communication on new vehicle sales tax data, Motor Vehicle Division, Department of Justice, Deer Lodge, Montana.

Murphy, M. (1995), personal communication, Bridge Bureau, Montana Department of Transportation, Helena, Montana.

National Automobile Dealers Association (1999), "Vehicles in Operation and Scrappage, Automotive Executive, August 1999.

Oregon Department of Transportation (1986), “Motor Vehicle Cost Responsibility Study”, Economics Unit, Planning Section, Highway Division, Oregon Department of Transportation.

Oregon Department of Transportation (1995), “Update of the 1992 Motor Vehicle Cost Responsibility Study”, Transportation Development Branch, Auto/Truck Section, Oregon Department of Transportation.

Stephens, J., Barth, T., and Cloud, W. (1992), “Cost Allocation Study for the Montana State Highway System”, prepared for the Montana Department of Transportation, Helena, Montana.

Stephens, J. et al (1996), ”Impact of Adoption of Canadian Interprovincial and Canamex Limits on Vehicle Size and Weight on the Montana State Highway System”, FHWA/MT-96/8113, U.S. Department of Transportation, Washington, D.C.

Sydec, et al (1994), “Highway Cost Allocation Study”, Final Report submitted to the Idaho Department of Transportation by Sydec, Inc., in association with Cambridge Systematics, Inc., and R.D. Mingo and Associates.

U.S. Department of Commerce, Bureau of the Census (1995), “1992 Census of Transportation, Truck Inventory and Use Survey, United States”, U.S. Department of Commerce, Washington, D.C.

Urban Institute, et al (1990), “Rationalization of Procedures for Highway Cost Allocation”, prepared for the Trucking Research Institute by the Urban Institute and Sydec, Inc. in association with KT Analytics, Inc. and Jack Faucett Associates, Inc.

10. TECHNICAL ADVISORY PANEL

The members of the technical advisory panel for this study from MDT were:

John Blacker	Head, Maintenance Division
James Currie	Deputy Director
Marvin Dye	Director, MDT
David Galt	Head, Motor Carrier Services Division
Gary Gilmore	Head, Highways and Engineering Division
Patricia Saindon	Head, Rail, Transit, and Planning Division
William Salisbury	Head, Administration Division